DEPARTMENT OF GEOLOGY
BUFFALO LIBRARY

Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

DECEMBER 1958

Experimental Missile Firings . . . . . Kurt H. Debus
ICBM Launch Control . . . . . Joseph E. Gallo
Support Systems for Liquid Engines . . . . . Powel Brown

Thiokol

HUNTER-BRISTOL

DIVISION—at BRISTOL, PENNSYLVANIA

Thiokol's Hunter-Bristol Division is an outstanding pioneer in rocket-powered test systems, such as rocket sleds to test pilot-ejection devices. Located at Bristol, Pennsylvania, Hunter-Bristol also produces aircraft and missile support equipment, air frame modifications, thrust and weighing stands and vital auxiliary power units. Its special engineering and production facilities are equipped to produce and test such equipment as igniters and fuses, as well as custom-engineered metal and electronic products for military and commercial use.

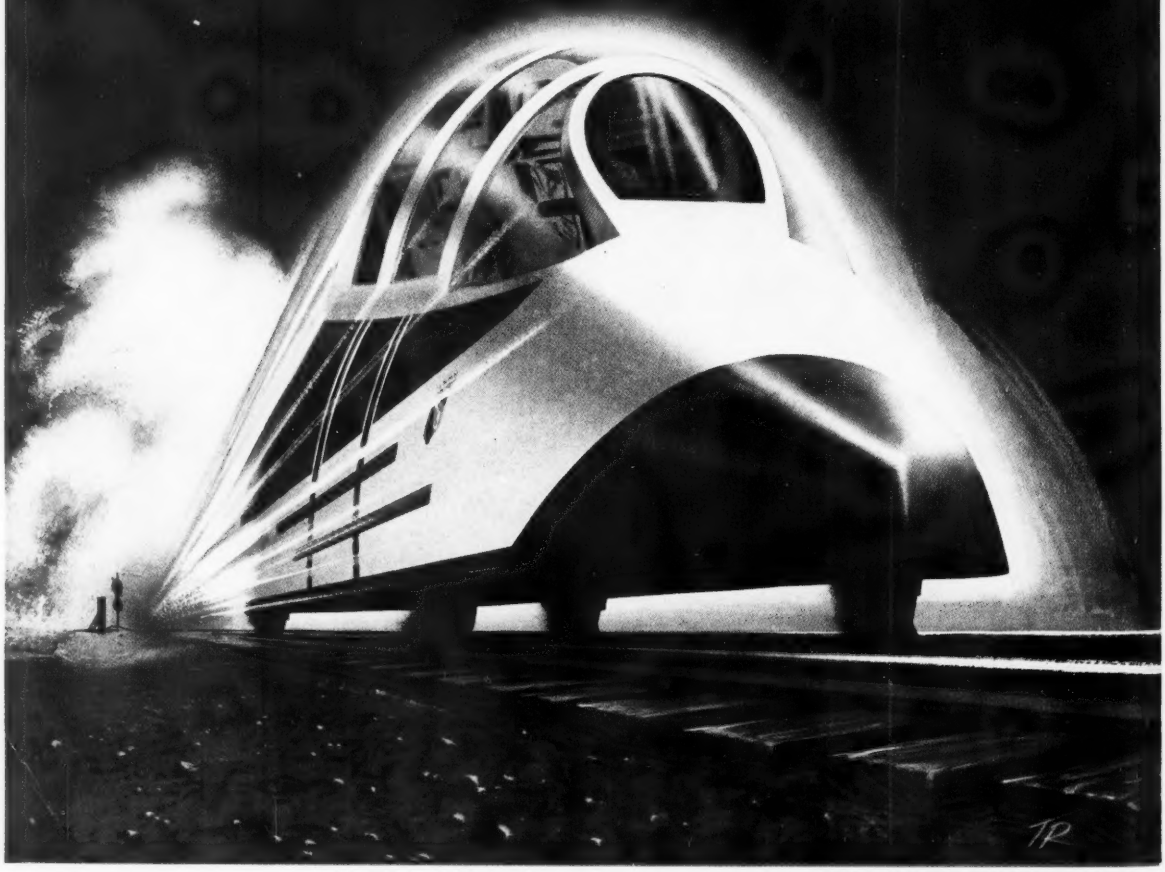
Engineers, scientists — perhaps there's a place for you in Thiokol's expanding organization. Our new projects present challenging problems and the chance for greater responsibility.

Thiokol®

CHEMICAL CORPORATION

TRENTON, N. J. • ELKTON, MD. • HUNTSVILLE, ALA. • MARSHALL, TEXAS • MOSS POINT, MISS.
BRIGHAM CITY, UTAH • DENVILLE, N. J. • BRISTOL, PA.

®Registered trademark of the Thiokol Chemical Corporation for its liquid polymers, rocket propellants, plasticizers and other chemical products.



Photograph courtesy General Electric Co.

magnesium . . . missiles . . . and manufacturing

Many magnesium alloys have the theoretical properties that missile designers need to give form and shape to their high-flying ideas. It's no wonder so many missile designers are relying on magnesium castings to keep their buzz birds trim and tough with a more-business-and-less-baggage punch.

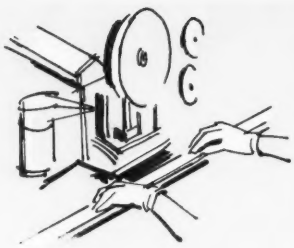
But before these magnesium-inspired ideas can graduate from the drawing board to "operational capabilities," they must go through that difficult stage known as "production." Here's where Rolle can take over for you. Design your magnesium castings as complicated as the application requires, and we'll worry about the production.

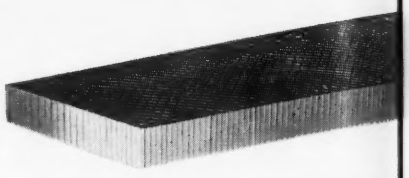
Our experience in missiles covers sand, permanent mold, shell, and investment castings of magnesium and aluminum . . . from some of the smallest to *the* largest magnesium casting made to date. In these castings is realized the full potential of the materials used and the highest level of dimensional accuracy.

For missiles with more wallop per unit weight, use magnesium alloys. For magnesium castings that meet your requirements exactly, make the most of Rolle's unrivalled experience in the field. A special Engineering Manual to help you design and specify aluminum and magnesium castings is available on letterhead request. Write for your personal copy to Rolle Manufacturing Company, 319 Cannon Avenue, Lansdale, Pa., Ulysses 5-1171.

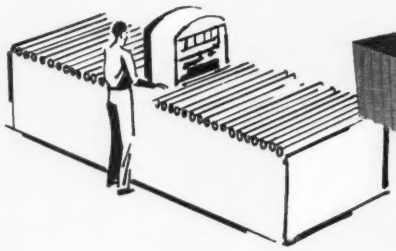
ROLLE

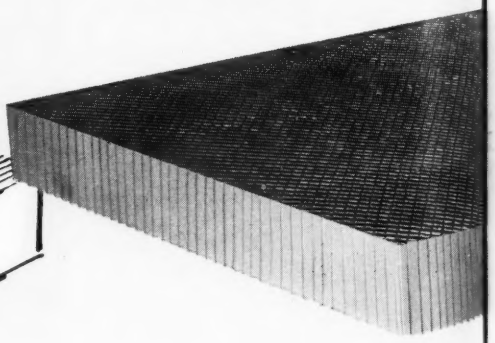
NOW IN PRODUCTION: 6 machines—a total of approximately 140 sq. ft. per day. Blankets 1 1/16" deep, up to 48" wide, 20 ft. long. Total of 9 machines will soon expand production to about 200 sq. ft. per day.



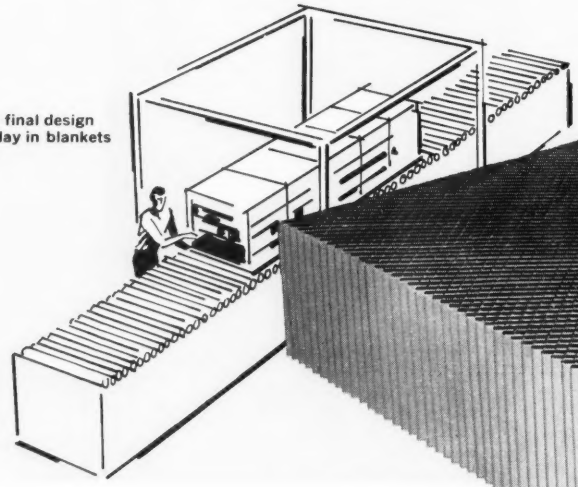


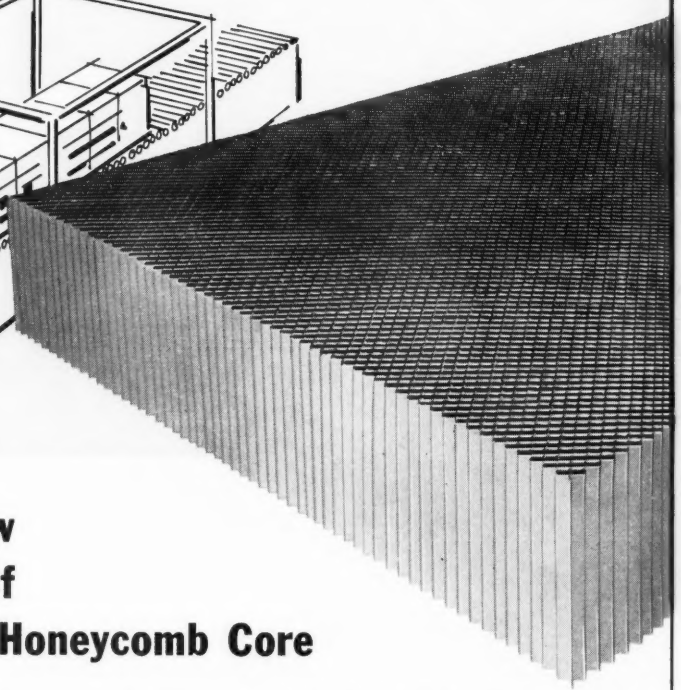
COMING SOON: a new machine with expected production rate of 6 cu. ft. per day. Planned blanket size 8" deep, 5 ft. wide, 5 ft. long.





IN DEVELOPMENT: machine in final design stage, promises 120 cu. ft. per day in blankets 12" deep, 4 ft. wide, 10 ft. long.





New Equipment at Swedlow Will Increase Production of High Temperature Welded Honeycomb Core

Larger blankets, greater cell depths and substantially increased quantities of welded honeycomb core will give designers new opportunities as Swedlow expands production facilities.

Engineers can now look forward to important new uses for high temperature honeycomb. Greater cell depths, larger blanket widths and lengths will be available in the near future. Increasing quantities will be produced by big, fast semi-automatic machines. This pioneering venture will result in larger core structures with strength-to-weight ratios not now obtainable. It foretells the machining of core in larger compound shapes. It is the long-awaited beginning of true large scale production of highest quality welded honeycomb core.

Swedlow precision standards will be pushed even further: uniform welds, close tolerances, uniform cell sizes and shapes, optimum node widths, flatness and bond strength, and elimination of the problems of canted cell walls. High strength-weight and rigidity-weight ratios, vibration damping and fatigue resistance – all these properties will be available for an ever increasing variety of corrosive and structural applications.

Depend on Swedlow for welded core blankets made of stainless steel and "super-alloy" materials in a growing number of constructions. For thorough technical service call or write the Swedlow plant nearest you. Please refer to Department 17.

Swedlow
PLASTICS COMPANY

Los Angeles 22, California • Youngstown 9, Ohio

Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY, INC.

December 1958 volume 3 number 12

Editor
IRWIN HERSEY

Technical Editor
MARTIN SUMMERFIELD

Consulting Editor
GEORGE C. SZEGO

Associate Editors
STANLEY BEITLER
JOHN A. NEWBAUER

Research Editor
GEORGE F. McLAUGHLIN

Art Director
JOHN CULIN

Contributors
Andrew G. Haley, Robert H. Kenmore, G. Edward Pendray, Kurt Stehling

Field Correspondents
Eric Burgess, Martin Caidin

Washington Correspondent
William R. Bennett

Contributing Artists
Mel Hunter, Fred L. Wolff

Advertising and Promotion Manager
WILLIAM CHENOWETH

Advertising Production Manager
WALTER BRUNKE

Advertising Representatives
D. C. EMERY & ASSOCIATES,
155 East 42nd St., New York, N. Y.
Telephone: Yukon 6-6855
JAMES C. GALLOWAY & CO.,
6535 Wilshire Blvd., Los Angeles, Calif.
Telephone: Olive 3-3223
JIM SUMMERS & ASSOCIATES,
35 E. Wacker Drive, Chicago, Ill.
Telephone: Andover 3-1154
R. F. PICKRELL & ASSOCIATES,
318 Stephenson Bldg., Detroit, Mich.
Telephone: Trinity 1-0790
LOUIS J. BRESNICK,
304 Washington Ave., Chelsea 50, Mass.
Telephone: Chelsea 3-3335
JOHN W. FOSTER
239 Fourth Ave., Pittsburgh, Pa.
Telephone: Atlantic 1-2977

EDITORIAL

17 From the Editor's Desk

FEATURE

18 Experimental Missile Firings—A Functional Analysis . . . . . *Kurt H. Debus*

TESTING, HANDLING, AND LAUNCHING

22 Atlas Handling from Factory to Launch . . . . . *Chester J. Dunn*
24 ICBM Launch Control . . . . . *Joseph E. Gallo*
26 Moon Probe Launch: What It Takes
28 Support Systems for Liquid Engines . . . *Powel Brown*
31 AF Logistics for Ballistic Missiles . . . . . *Col. Henry G. Macdonald*
32 Universal Engine Handling Equipment
33 Toward Universal Missile Test Systems . . *Robert Gray*
34 GSE Design Criteria . *L. W. Schopp and C. E. Fordham*
36 Early Testing Means Better Ground Support Equipment . . . . . *Charles Johnson*
38 Corrosion Prevention for Polaris . . . *H. C. Slaughter*
40 The Polaris Launching System . . *Capt. Dennett K. Ela*
42 ASM Handling and Launching . . . . . *Kenneth L. Levin and David Feld*

ARS ANNUAL MEETING

44 Astronautics at the Statler . . . . . *Irwin Hersey*

NEWS

21 Space Beacon
46 The X-15: Mach 7 Aircraft

ANNUAL INDEX

102 Index to *Astronautics*, Vols. 2–3

DEPARTMENTS

5 Astro Notes
12 Capital Wire
14 For the Record
14 International Scene
48 Missile Market
54 ARS News
56 On the Calendar
72 People in the News
90 Government Contracts
92 In Print
106 New Products
108 Index to Advertisers

ASTRONAUTICS is published monthly by the American Rocket Society, Inc., and the American Interplanetary Society at 20th & Northampton Sts., Easton, Pa., U.S.A. Editorial offices: 500 Fifth Ave., New York 36, N. Y. Price $9.00 a year; $9.50 for foreign subscriptions; single copies $1.50. Second-class mail privileges authorized at Easton, Penna. © Copyright 1958 by the American Rocket Society, Inc. Notice of change of address should be sent to Secretary, ARS, at least 30 days prior to publication. Opinions expressed herein are the authors' and do not necessarily reflect those of the Editors or of the Society.

We build GSE* for the big ones

***Ground Support Equipment—unsung hero of the launching pad**

We have built a substantial part of the Ground Support Equipment for Jupiter, Atlas and Thor—as well as the GSE for our own GAM-77, a new air-to-surface missile for Boeing's B-52. We've designed and built GSE for rocket, ramjet, and turbojet craft for 12 years . . . proved its reliability in thousands of actual test firings.

Consoles, actuators, stands, dollies, platforms, trailers, power supplies, engine servicers, starters, erectors etc., etc. You name it . . . we've built it.

Whether it's a crash program or a long range project . . . single piece of hardware or complete ground support system . . . we'll build it to your prints or do the whole package from R&D through manufacturing.

Also, our experience has taught us how to *organize* as well as execute. We call it systems-management capability. Businesslike. On schedule. It means time and money saved for you.

Write or call: Special Products Manager, Missile Division, 12214 Lakewood Boulevard, Downey, California.

MISSILE DIVISION
NORTH AMERICAN AVIATION, INC.

Astro notes

MAN IN SPACE

• The 38 industrial concerns at NASA's space-capsule conference, held at Langley Research Center last month, received specifications for a manned satellite to ride Atlas-D in place of a nose cone and orbit the earth circularly with an apogee of 120 n. mi. Expected to weigh some 2200 lb as orbited, the cone-shaped satellite will use jets to control roll, yaw, and pitch; retro-rockets to slow re-entry; a metal re-entry heat shield ejectable before landing; a drogue parachute for final deceleration; and a rubber landing pillow and float. The satellite will be capable of operating 40 hr manned or unmanned. Intended for water landing, it will have sufficient protection to sustain a land drop. Bids were to come in by Dec. 4.

• ARPA also pushed work on a manned satellite program by awarding a $9 million beginning contract to Pratt & Whitney Div. of United Aircraft Corp. for development of a liquid-hydrogen-fueled second-stage motor capable of use with Atlas. In ARPA's program, it is expected Convair-Astronautics will adapt Atlas as a first-stage booster and will probably build the satellite capsule, an experimental version of which is already in ground testing.

• NASA and ARPA, realigning plans for the man-in-space program, have dropped preliminary tests with small satellite capsules, and will work exclusively with large-scale space capsules—first with air drops, then ballistic trajectories, and finally as true satellites. NASA's Langley Research Center is now conducting air-drop tests of satellite capsules to check parachute operation. Rationale of this approach: It would cost more to engineer a small model capsule followed by the full-scale system than it would to stick exclusively to man-sized space capsules.

• Still unanswered is the question of how much animal testing will be necessary before a man is committed to a ballistic trajectory and finally a satellite. The government would like to minimize costly animal tests, but the exact nature of the risks involved are not clear. A careful assessment of medical opinion on the question is now under way.

• A good portion of that medical opinion congregated at the 2nd International Symposium on the Physics and Medicine of the Atmosphere and Space, held at San Antonio, Tex., the second week in November, to hear papers on space environment, vehicles, medical problems expected in the first, nearby space ventures and in long flights to other plants, and rescue in space.

• News from San Antonio on the radiation belt read like this: The Explorers showed very little radiation at altitudes up to 100 miles, but a sharply progressive rise in radiation above that altitude to 1200 miles, as reported by Albert Hibbs in the November ASTRONAUTICS. Pioneer gave no data between altitudes of 1200 miles and 3.83 earth radii. Between 3.83 and 5.62 earth radii, Pioneer's counter showed radiation dropping from 5.5 to 0.2 roentgen. These latter radiation figures are taken as low limits, inasmuch as the counter on Pioneer "leaked." According to James A. Van Allen, the heart of the radiation belt, which he sees as roughly doughnut-shaped and girdling the earth, with relatively radiation-free "cones" at the poles, lies about 4000 miles up and has an intensity of at least 100 roentgens per hr and perhaps as high as 1000. A lifetime dosage for man is roughly 100 roentgens. Also, it was reported that there now appears an intimate relation between the radiation belt and auroral phenomena.

• ONR's Strato-Lab program is being extended in study form by Vitro Labs to a manned stratosphere laboratory capable of prolonged work at an altitude of 100 to 120 thousand feet. This balloon-lofted lab would give substantially better conditions for observing the planets than Strato-Lab IV, with its limit of 80,000 ft.

• Four months ago, the Russians reportedly fired a single-stage rocket with a 3726-lb capsule containing two dogs to an altitude of 280 miles, and recovered capsule and dogs in good condition. The Russian man in space appears fast approaching.

SPACE PROBES

• Failure of AF's third attempt to loft a scientific payload to the moon put the spotlight on the Army, which has been assigned two Juno II lunar probes—that is, vehicles similar to Jupiter-C except that a Jupiter booster replaces the Redstone first stage. According to Wernher von Braun, the 15-lb Army probe has a one-in-two chance of escaping the earth's gravitational field and reaching the moon, a one-in-three chance of telemetering useful data all the way. Designed for lunar impact, rather than orbit, the shot will be less sophisticated than AF moon probes and will use a higher velocity, permitting a velocity error of 158 meters per sec, compared wth 2 meters per sec for minimum-energy transfer. High velocity will cut transit time to 33 hr, 45 min, considerably less than in AF attempts. Shot is set for Dec. 5 if the vehicle can be readied by that date.

• Exact nature of payload and destination of two extra Thor-Able vehicles made available to AF by NASA has not as yet been determined, although an attempt to probe Venus is a possibility, since such a flight would require only a 1 per cent velocity increment. The vehicles are not expected to be ready before February. AF also hopes to work with NASA on program for placing satellites in high-altitude elliptical orbits, and may do some satellite work for ARPA.

MISSILES

• Except in numbers too costly to be practical, Nike-Zeus will not give effective defense against ballistic missiles used in conjunction with decoys (such as metallized balloons that look like BM warheads to conventional radar), small transmitters released by them to block defense radar, or multiple warheads, according to ARPA scientist Richard Holbrook. ARPA plans $100 million this year for studies of new ideas for anti-missile defense.

• First flight test for Titan ICBM is scheduled this month. Dummy second stage will be used in the test.

• Assisting Boeing in assembly and test of Minuteman will be AT&T on communications, Bechtel Corp. on launching sites, and Four Wheel Drive on ground-handling equipment.

R&D

• Successful firing of a prepackaged liquid motor of 50,000 lb thrust gave advocates of self-contained liquid engines for ballistic missiles a peg to hang their hopes on. Much larger units now appear a possibility.

• Storing highly reactive propellants in microscopic-sized polymeric capsules, which can be caked to give something like a solid propellant or flowed through orifices like a liquid, offers another approach to self-contained systems. National Cash Register of Dayton, which demonstrated this technique with jet fuels, has begun research to adapt it to high-impulse propellants.

INDUSTRY

• Marquardt Aircraft's revamped Jet Lab in Van Nuys, Calif., will permit testing 6-ft-diam ramjet engines at simulated altitudes of near 200,000 ft and Mach numbers up to 4.5.

• North American Aviation formed a special group within Rocketdyne to work on the ARPA-ABMA clustered-engine program, first project of which is the H-1 satellite booster—eight Jupiter engines developing joint thrust of 1.5 million lb.

For Rocket, Aircraft, and Ground Support

TELEMETERING, INTERLOCK, CONTROL, SEQUENCING, TIMING, ARMING AND COMMUNICATIONS

A CLOCK WITH NO MOVING PARTS

The Transistorized Network Timer is designed for accurate sequential operation, as an interval timer, for use as an initial time delay in "warm-up" circuits, for step switching, safety interlock applications and arming delay circuits.

This timer features accurate settings from 1 to 60 seconds held to ±5% over the environmental range. Contacts are instantly resettable in less than .020 seconds. The unit will operate in tolerance from 18 to 29 VDC; other volt ranges are available. Ambient temperature may vary from −55 to +125°C, vibration 15g's to 2000 CPS, shock 50g's 11 ±2 milliseconds.

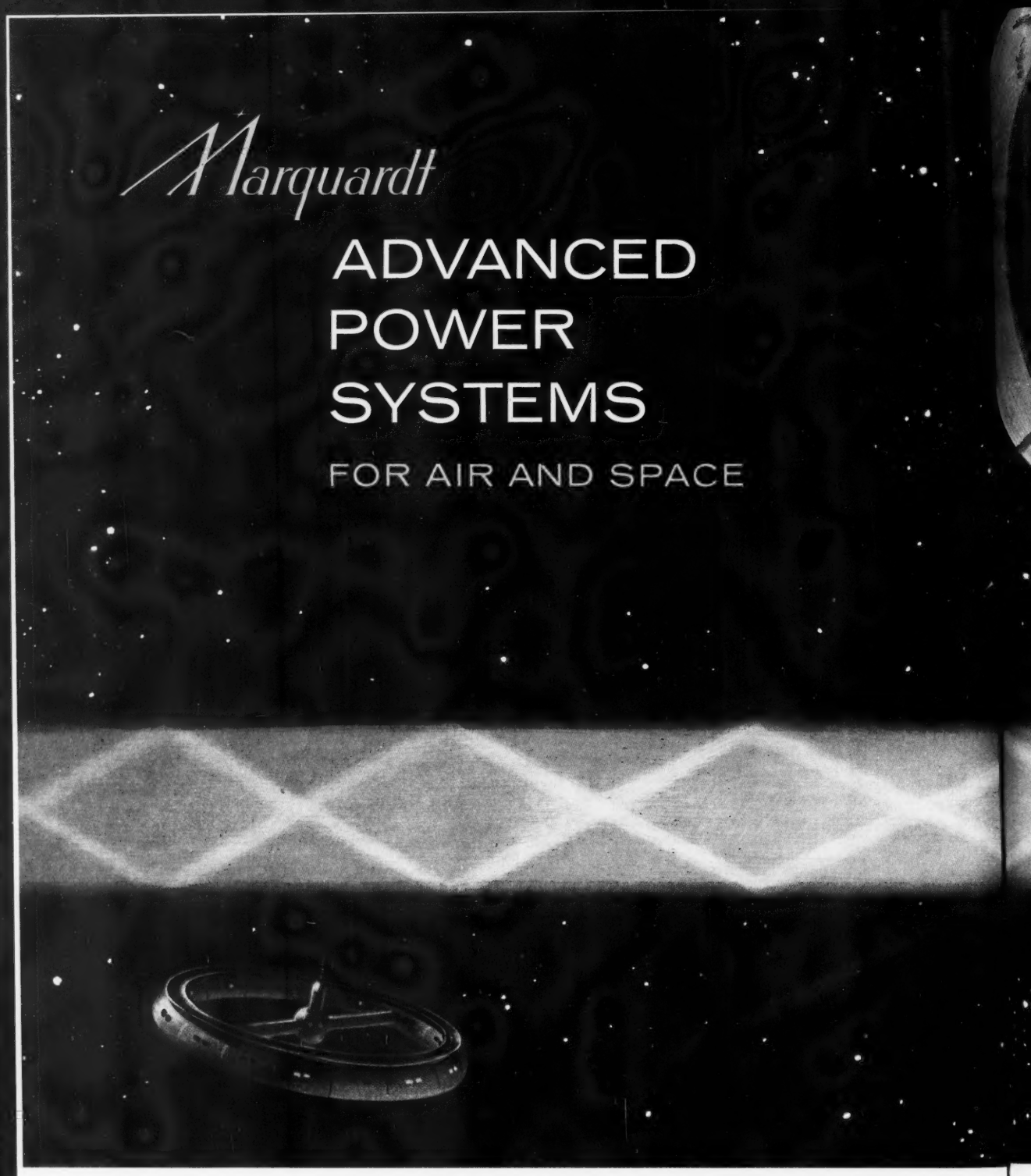
Designed to conform to MIL-R-25018, Class B, Type II, Grade 3 as outlined above, this network timer has two pole double throw contacts rated 2 amps. resistive, 1 amp. inductive at 28VDC. The unit volume is 4½ cubic inches and weight .45 lbs. This timer uses a transistor controlled RC circuit with no moving parts.

DIAPHLEX
Division of
COOK ELECTRIC COMPANY
Chicago, Illinois, U.S.A.

Cook Electric Company

2700 SOUTHPORT AVE., CHICAGO 14, ILLINOIS

DIAPHLEX—Aircraft Components and Accessories. **COOK RESEARCH LABORATORIES**—Basic & Applied Research. **INLAND TESTING LABORATORIES**—Qualification, Environmental, Reliability and Radiation Testing. **MAGNILASTIC**—Expansion Joints and Large Scale Metal Fabrications. **WIRECOM**—Wire Communication Protection & Distribution Equipment. **ELECTRONICS SYSTEMS DIVISION**—Engineering and Production of Electronic Gear. **AIRMOD**—Modernization, Modification, and Repair of Aircraft. **NUCLEDYNE**—Engineering and Design of Highly Complex Type Facilities. **CINEFONICS, INC.**—Motion Picture Production. **CANADIAN DIAPHLEX, LTD.**—Aircraft Components and Accessories.



Projects meeting the ever increasing needs of Advanced Power Systems for Air and Space operations are currently under way at Marquardt. Here, in an environment that stimulates creative hypotheses, Marquardt engineers and scientists are engaged in the following diversified areas:

ADVANCED PROPULSION CYCLES

- Ramjets for cruise propulsion for hyper-velocity missiles and piloted aircraft and as accelerating devices for Space Vehicles
- Electrical Propulsion—Plasma Jets, Ion Propulsion and Magnetohydrodynamics
- Nuclear Ramjet

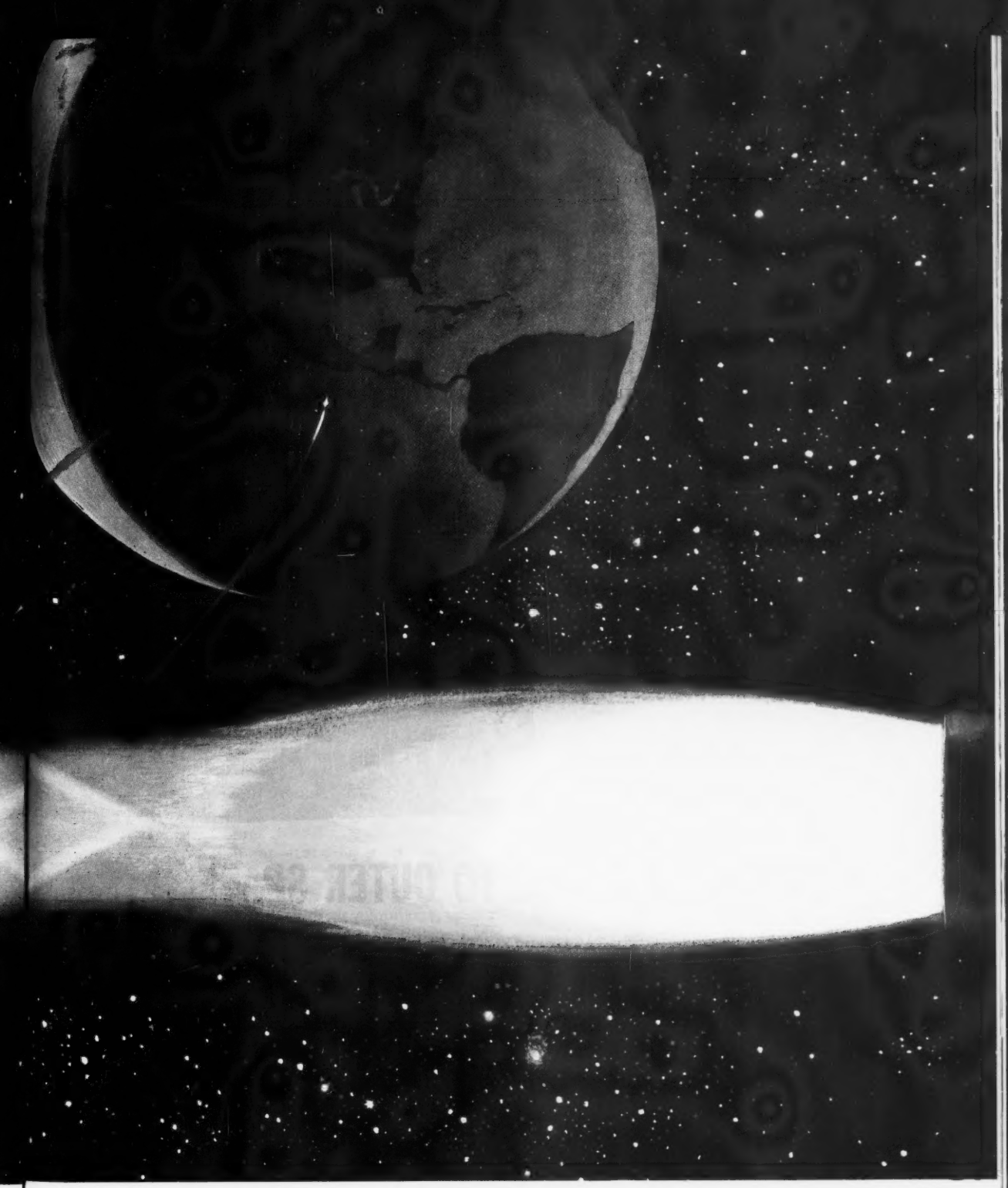
EXOTIC FUELS

- Evaluation—Energy, Compatibility and Logistics

CONTROLS & ACCESSORIES

- Hot Gas Servo Systems
- Accessory power for Space application
- Variable geometry Inlet Controls

In addition, current application projects include supersonic ramjet power for Bomarc, Super Bomarc, X-7 (test vehicle), Q-5, and Kingfisher.



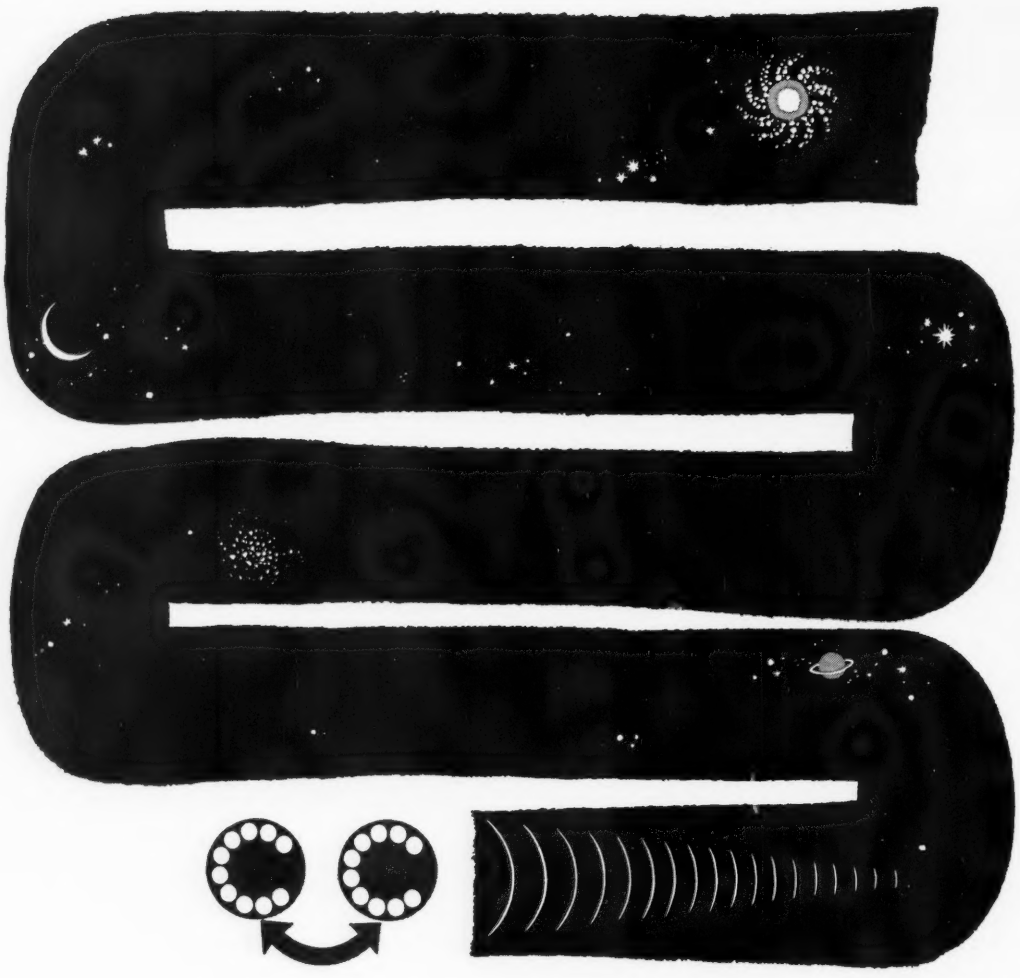
TO ENGINEERS AND SCIENTISTS:

Engineers capable of contributing to advances in the state-of-the-art and scientists who desire to do proof-of-the-principle research in the fields of propulsion systems, automatic controls, advanced test facilities and high temperature materials may find, here at Marquardt, the climate best suited to your interests and talents.
May I suggest that you contact me?

Roy E. Marquardt
President

Marquardt
AIRCRAFT CO.

VAN NUYS AND POMONA, CALIFORNIA · OGDEN, UTAH



FROM INTER-OFFICE TO OUTER SPACE...

The telephone rings. You lift it and talk to an associate in the next office.

A countdown reaches zero at Cape Canaveral. Minutes later a new satellite radios its position . . . in orbit a hemisphere away.

One of these events is today commonplace . . . the other, still spectacular. To the 128,000 men and women of International Telephone and Telegraph Corporation, both are episodes in a never-ending drama called *communications*.

It means many things

At ITT communications is submarine cable, radio-telegraph, microwaves beamed over valleys and seas. At the world's great airports, it is the Instrument Landing System. It is TACAN and VORTAC, electronic air-navigation safety aids for civil and military flying.

Communications is guidance systems for rockets and missiles. It is over-the-horizon TV. It is the technical training and manpower ITT provides for the Distant Early Warning (DEW) Line in the Arctic. It is a new, world-wide control system for the Strategic Air Command.

Where ITT stands today

ITT stands in the forefront of research . . . and on the threshold of new achievements. Its systems, equipment and services embrace virtually every field of electronics. In fact, you'll find ITT everywhere—from inter-office to outer space.

ITT

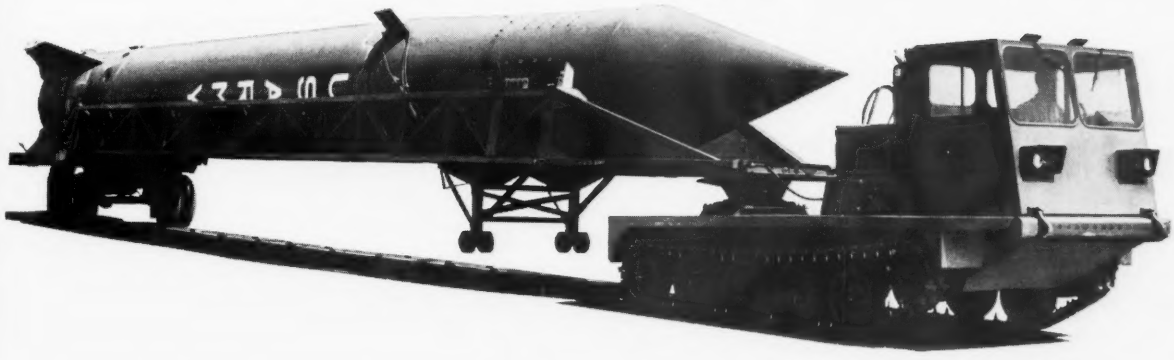
. . . the largest American-owned world-wide electronic and telecommunication enterprise, with 80 research and manufacturing units, 14 telephone and telegraph operating companies and 128,000 employees.

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION 67 Broad Street, New York 4, N.Y.

FARNSWORTH ELECTRONICS COMPANY • FEDERAL ELECTRIC CORPORATION • FEDERAL TELEPHONE AND RADIO COMPANY • ITT COMPONENTS DIVISION
ITT INDUSTRIAL PRODUCTS DIVISION • ITT LABORATORIES • INTELEX SYSTEMS, INC. • INTERNATIONAL STANDARD ELECTRIC CORPORATION
KELLOGG SWITCHBOARD AND SUPPLY COMPANY • ROYAL ELECTRIC CORPORATION • AIRMATIC SYSTEMS CORPORATION • AMERICAN CABLE & RADIO CORPORATION • LABORATORIES AND MANUFACTURING PLANTS IN 20 FREE-WORLD COUNTRIES

...speaking of

Missile Ground Support **MOBILITY**



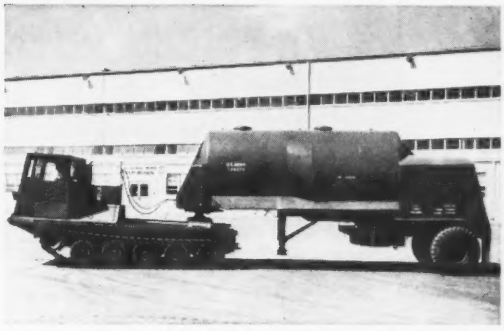
U.S. ARMY PHOTOS

WE MAY HAVE THE SOLUTION TO YOUR PROBLEM

When the Army Ballistic Missile Agency needed a small, lightweight prime mover sufficiently versatile to transport almost any size or kind of load, even over terrain inaccessible to other types of powered equipment, they came to FMC – and the ABMA Tractor was born.

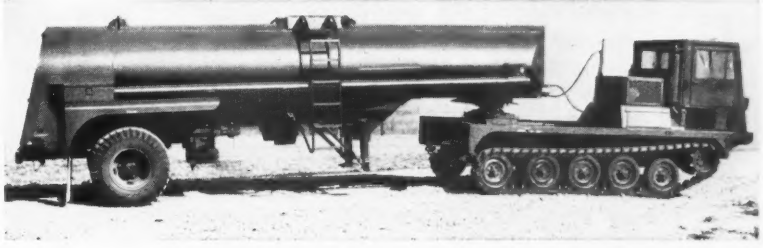
This powerful multi-purpose tracked vehicle, conceived and produced by FMC for an Army development program, is another result of the more than 17 years experience acquired by FMC in designing and building more types of military-standardized tracked vehicles than any other company in America. FMC's accumulation of applied knowledge and experience in the field of mobility has led to the development and manufacture of missile ground support equipment – ranging from small tracked vehicles, transportable by helicopter, to complete missile launching systems.

From design concept through development, engineering and production – to delivery on schedule – FMC is qualified to help you solve your missile project problem. *Why not consult with FMC at the initial stage of project planning?* Contact us today for more information.



As a multi-service prime mover, the FMC-built ABMA Tractor is powered for moving heaviest loads on short or long hauls with ease and dispatch. This sure-footed, tracked vehicle handles all types of trailers, is equally capable on soft, rough or surfaced ground.

Creative Engineers: Find stimulating challenge at FMC's Ordnance Division.



Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

Ordnance Division

Missile Equipment Section 2-J

1105 COLEMAN AVENUE, SAN JOSE, CALIF.

Capital wire

News highlights from Washington

MISSILES

• The Navy's long-legged Eagle air-to-air missile system appears to be in funding difficulties. At this writing, the sailors have narrowed down the 17 bidders to one recommended contractor and two alternates. Although the Navy did not call for an aircraft proposal along with the Eagle system, at least one bidder included a parametric design study for a suitable vehicle.

• The Army has ordered design studies from four companies on a new lightweight AA missile system called Mauler. The weapon would be used for protection of truck convoys, front-line troop concentrations and other relatively small targets. The system would bear the same relation to the Army's 50 cal machine guns that Hawk and the Nike family bear to the 75 mm and 90 mm rapid-fire cannons.

• Watch for the AF to order a design competition for an airborne IRBM early next year. The weapon will be designed for use with the North American's six-jet B-70, but is also expected to be available to extend the service life of the AF fleet of Boeing B-52 heavy bombers.

• AF Minuteman ICBM weapons will have one-third the gross weight of the 100-ton Atlas and Titan missiles, and a fraction of the reaction time. Minuteman will carry only one-fourth the destructive warhead of Atlas and Titan. Under present plans, it would be used against area targets with little hardening, such as cities, while the Atlas and Titan would be utilized against hardened pinpoint targets like enemy ballistic missile sites.

LUNAR PROBES

• A post-mortem of the Oct. 11 moonshot disclosed that the Aerojet second stage was shut off when it still had enough propellant to accelerate the vehicle an additional 1500 fps, or almost twice as much as the deficit of 800 fps. The premature shutoff resulted from a miscalculation of the amount of impulse the untried Allegany Ballistics Lab third stage would supply.

• The two additional Thor-Able I vehicles ordered in August by ARPA are expected to be available early next year, either for launching heavier satellites or for more advanced space probes. ARPA officials scoff at reports that they might be devoted to such ambitious uses as probing Venus.

SATELLITES

• Army Signal Corps scientists have achieved a tracking accuracy of about one minute of arc with respect to the 3-lb Vanguard test satellite, still broadcasting after eight months in space. This is comparable to the Soviet claim of 80 m accuracy at Sputnik III perigee. The Map Service scientists use a specialized adaptation of the Minitrack system to follow the Vanguard, but it is not clear how the Russians have managed to attain their claimed accuracy. Robert Jastrow of NRL discounts the possibility that the Russians are using optical means to pinpoint Sputnik III in view of the small number of photos they have obtained. It is believed radio tracking would be hampered by the lower frequency and greater attenuation of the Sputnik III broadcasts.

• Precision measurements of precession of the plane of Vanguard's orbit have shown that the earth is some 300 ft thicker at the poles than is indicated by American maps. Contrary to general belief, the new figure on the earth's oblateness will have little effect on the operation of ICBM's. Its chief value is that it shows the earth is more rigid than prevailing geological theories indicate.

• Next Vanguard attempt was expected late in November or early December. NRL scientists plan to repeat the ill-fated cloud cover experiment. The magnetometer satellite attempt, which was next in line, was postponed for a later try.

MAN IN SPACE

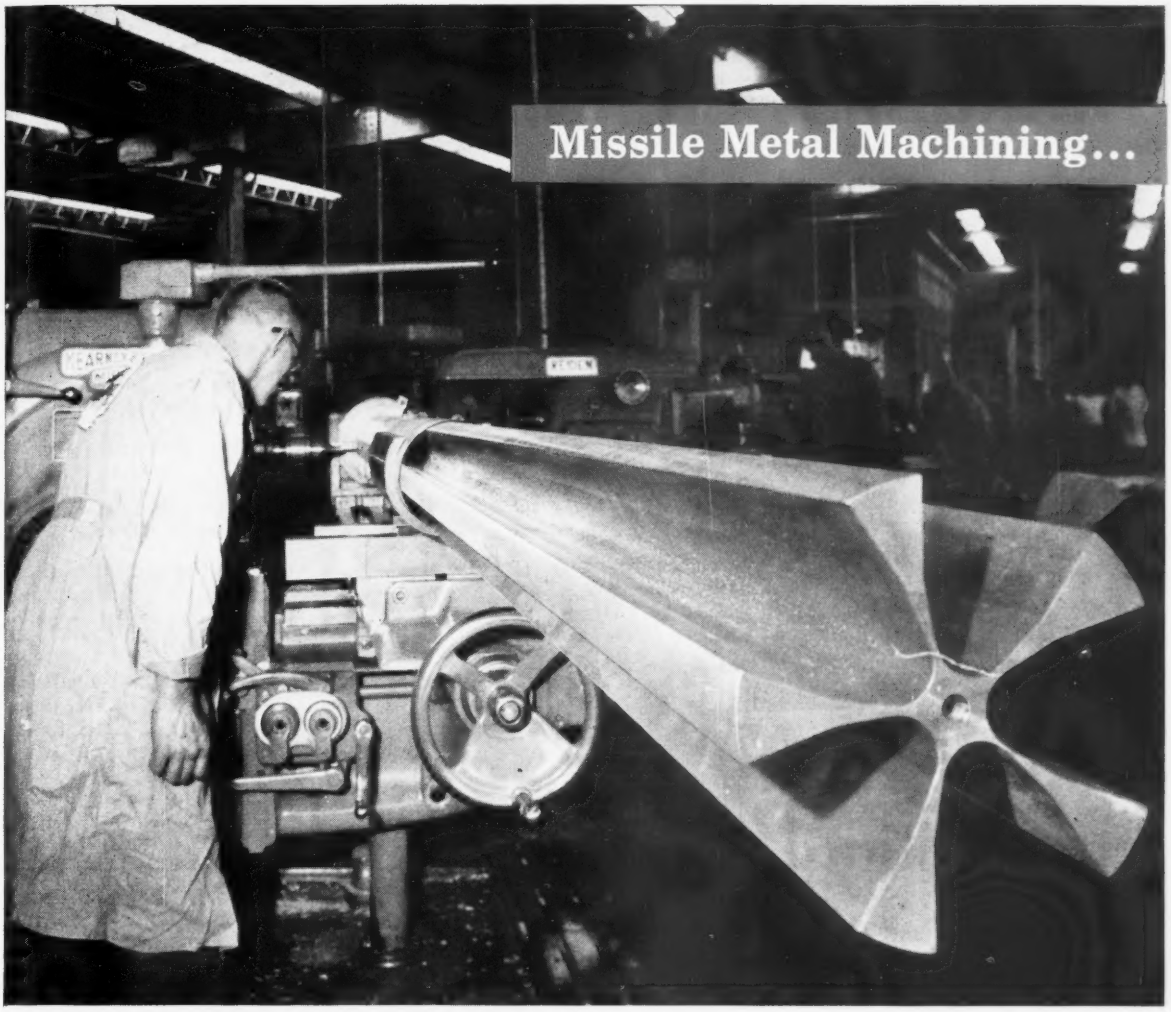
• NASA expects to award a contract early next year for design and construction of "flyable mockups" of space capsules. The mockups would be launched initially on ballistic trajectories and would pave the way for full-scale manned satellite capsules. NASA outlined its requirements at a bidders conference at Langley Field, Va., early last month. It indicated its man-in-space program has been expanded considerably beyond the five model and two full-scale capsule flights proposed to Congress last summer.

• North American is working with Boeing on a study of a recoverable booster for a manned satellite launching vehicle. It is presumably an advanced development of its concept for a recoverable piloted booster for the Dyna-Soar. NAA is also conducting a study for the Army on the economics of recoverable boosters for ballistic missiles. The principle might be used to cut the cost of training exercises.

NASA

• NASA Administrator Keith Glennan appeared to be making headway in his effort to secure the transfer of portions of ABMA and JPL to his agency. Although the Army fought the proposal bitterly, it appeared that top-level sentiment at the Pentagon favored the transfer. For the National Space Council, the chief problem seemed to be that of facilitating the transfer without frustrating the Army's genuine need for missile scientists and facilities.

• Before settling on ABMA and JPL as the facilities it wants to support its space projects, NASA teams surveyed and rejected a number of other possibilities. Among these were the Army Signal Corps R&D Center, NOTS and the Naval Electronics Center. Military commitments of most of these organizations precluded their use for civilian space work.



If it can be put on paper...

Above you see a solid propellant rocket core mold being completed after taper milling and contour turning by a Diversey craftsman. Diversey produces so many tough and intricate missile components similar to the above that no wonder everyone calls them the most versatile missile metal machinists in the USA. Diversey does outstanding work in the machining of missile components because they have the largest facilities, the finest machinists and top flight engineering.

If it can be put on paper, Diversey can put it into metal.

HYDROSPINNING NOW AVAILABLE

A new Hydrospinning Division has been formed at Diversey which uses the latest and largest equipment to produce intricate missile parts.

SEND FOR FREE BOOKLET

LEADERS IN CONTOUR MACHINING

Diversey ENGINEERING COMPANY

10550 WEST ANDERSON PLACE
FRANKLIN PARK, ILLINOIS • *A Suburb of Chicago*

FROM NOSE TO NOZZLE, FROM FIN TO FIN, CONTOUR TURNED PARTS—WITH PRECISION BUILT IN

For the record

The month's news in review

Oct. 1—NASA commences operation.

Oct. 3—ICSU sets up COSPAR to study plan for permanent international cooperation in space research.

Oct. 8—Soviet IGY committee gives U.S. telemetry code covering space radiation measurements made by Sputnik III.

—AF balloonist rises to 99,600 ft.

Oct. 9—Army Jupiter blows up 20 sec after launching.

Oct. 10—Navy unveils $3 million Polaris simulator.

Oct. 11—AF Pioneer lunar rocket fails to orbit moon, but reaches 80,000 miles into space. Initial success was reported in relaying single radio signals transocean via Pioneer from Cape Canaveral to Jodrell Bank radio telescope, Manchester, England, where they were picked up.

—U.S. IGY team fires five research rockets during solar eclipse.

—AF tentatively sets Nov. 7 for next moon shot, gets two extra probes in addition to three lunar shots assigned last spring.

Oct. 14—Army is asked by NASA to turn over ABMA "team" and JPL to civilian space flight effort.

Oct. 15—X-15 rocket research aircraft unveiled.
—Polaris is destroyed as launching fails.

Oct. 19—Report of House Select Committee on Astronautics and Space Exploration urges U.S. to push peaceful conquest of space.

Oct. 22—Army R&D Chief Lt. Gen. Arthur G. Trudeau and Ordnance Missile Command Chief Maj. Gen. John B. Medaris warn against break-up of Army missile and space scientist team.

Oct. 23—Army launches Jupiter-C rocket, but fails to orbit 12-ft balloon.

Oct. 27—ARPA initiates major research program aimed at development of high-energy solid fuels.

Oct. 28—Rocket observations of Oct. 12 solar eclipse show X radiation comes from sun's corona and ultraviolet radiation originates near the chromosphere.

Oct. 30—William M. Holaday, Director of Guided Missiles, is appointed chairman of the Civilian-Military Liaison Committee, provided for in NASA act.

International scene

BY ANDREW G. HALEY

The International Astronautical Federation was afforded unprecedented recognition at the eighth General Assembly of the International Council of Scientific Unions (ICSU) by the unanimous adoption of a resolution reading:

"The General Assembly is aware of the useful activities of the International Astronautical Federation (IAF) in furthering the science and technology of astronautics. The General Assembly welcomes the interest shown by the International Astronautical Federation (IAF) in furthering the International Council of Scientific Unions and looks forward to the possibility of arranging in the future a more formal affiliation in matters of common concern."

° ° °

The foregoing action is the latest in a long series of negotiations between the IAF and ICSU. Until 1957, no progress was made in establishing relationships. In 1957, L. V. Berkner, then president of ICSU, and the writer exchanged correspondence, which led to a meeting last April and formation of an ad hoc committee.

The stated objective of the Committee was to set up immediately an ad hoc Exploratory ICSU/IAF Committee to examine the possibilities of making contact between ICSU and IAF. It was also proposed that the IAF consider the possibility of sponsoring a scientific union, or, alternatively, of reorganizing.

The committee met in Moscow last August, and at this meeting, the committee unanimously recommended to ICSU that the IAF be considered for recognition as an international organization rendering valuable services to the science and technology of astronautics.

° ° °

In accordance with the regular procedures of ICSU, the report was considered at the meeting in Washington of the ICSU Executive Board on Oct. 1, prior to General Assembly consideration on Oct. 6. The writer, as IAF President, was afforded full observer privileges at the board and assembly sessions and was advised in advance quite frankly by Dr. Berkner that the recognition request was unprecedented, and would be denied by the board on the ground that IAF would first have to reorganize to set up a division concerned solely with the appropriate natural sciences.

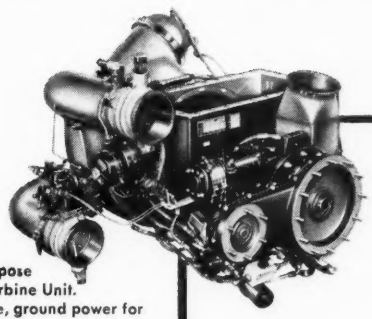
In the meantime, and for at least one year, scientific astronautical activity could be pursued by a previously agreed upon International Committee on Space Research, composed exclusively of existing ICSU members. This latter fact is significant, as ICSU did not reach out to include non-members, such as the IAF, on the committee.

° ° °

This development had been anticipated at the IAF Amsterdam Congress in a meeting of the IAF-ICSU Cooperation Committee under the chairmanship of Dr. von Kármán, which recommended that the IAF form three Divisions—for Space Sciences, Space Technology, and Social Sciences Related to Space Problems.

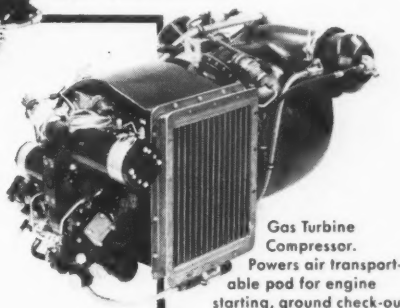
The Division of Space Sciences would be concerned with the broad spectrum of physical, mathematical, astrophysical, and like sciences related to the study of space, and, the committee felt, would be qualified as one of the participating groups of the proposed Space Science Commission of ICSU. (CONTINUED ON PAGE 80)

AiResearch gas turbines proved most versatile and reliable...



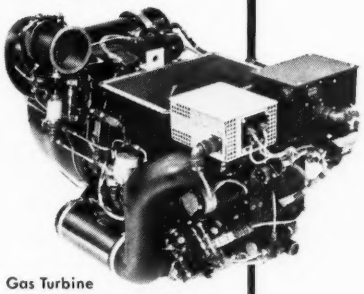
Multipurpose Gas Turbine Unit. Airborne, ground power for heating, cooling, starting, electrical, hydraulics, pressurization of military aircraft.

Gas Turbine Power Unit. Aircraft and missile ground support to drive generators, pumps, compressors. Weighs only 45 lbs.

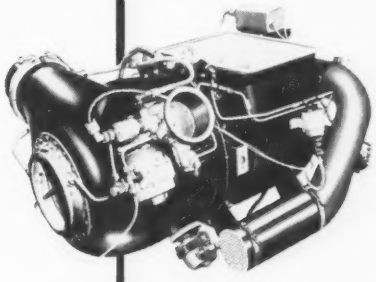


Gas Turbine Compressor. Powers air transportable pod for engine starting, ground check-out, ice and snow removal.

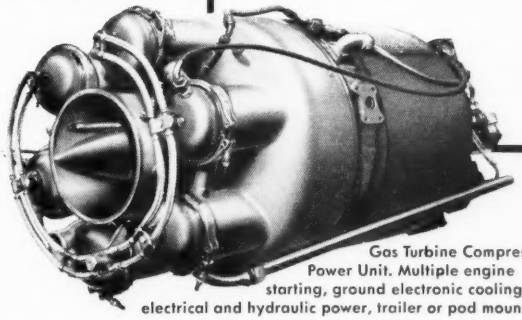
8,000 now in operation



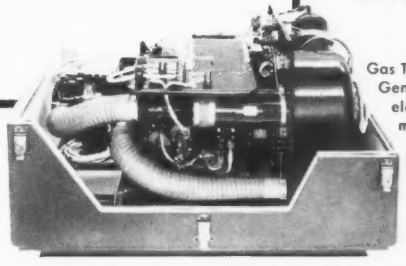
Gas Turbine Compressor. Standby in-flight pneumatic power for turbine-powered transports.



Gas Turbine Compressor Power Unit. Electrical and pneumatic ground power source for jet transports.



Gas Turbine Compressor Power Unit. Multiple engine starting, ground electronic cooling, electrical and hydraulic power, trailer or pod mounted.



Gas Turbine Generator Set. Primary electrical power for missile launchers, guidance and refrigeration systems.

AiResearch Gas Turbines are used in hundreds of applications: auxiliary power and ground support for missile systems, military and commercial aircraft; main engine starting, electrical and pneumatic power, air conditioning, pressurization, pre-flight check-out, snow and ice removal; prime power for helicopters; variety of ground applications or aboard aircraft for mobile or stationary use.

Advantages: these lightweight units are air transportable as fixed installations, detachable pods or portable vehicles; supply low pressure air and shaft power from 30 H.P. to 850 H.P.; provide variety of electrical power — 9 to 150 KW, 60, 400 and 1200 CPS, AC or DC; have highly refined self-regulating controls and operate in any weather; have instant push-button starting; time between overhauls 1000 hours or 3000 starts.

Your inquiries are invited.

ENGINEERING REPRESENTATIVES: AIRSUPPLY AND AERO ENGINEERING, OFFICES IN MAJOR CITIES

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

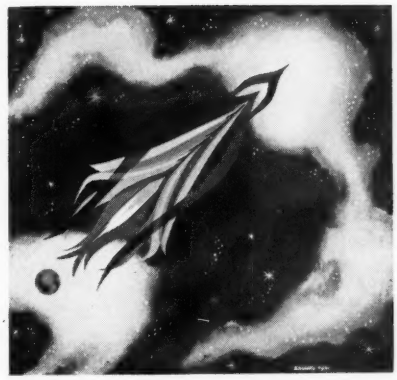
No birth pains . . . when continuous stream analysis attends missile loading.

Safety is critical. An infinitesimal trace of moisture can freeze controls and valves...the oil from a fingerprint can cause an explosion. Even oxygen in the air you breathe becomes a dangerous contaminant. ☒ Continuous stream analysis is the only basis for safe fueling on the launching pad, for fuel mixing remote from the pad, even for fuel processing during manufacture...and Beckman process instruments deliver sure safety control quickly and accurately. ☒ The Model 21 Infrared Analyzer detects hydrocarbons 0-3 ppm safely within military requirements for compressed missile gases. Electrolytic Hygrometers monitor inert gas streams for as little as 0-10 ppm moisture (1 ppm is equivalent to a dew point of −100°F). Models F3 and G2 Oxygen Analyzers monitor inert gas streams for traces of undesirable oxygen and monitor oxygen streams for gas purity. ☒ For detailed information on these stream analyzers, ask for Data File 2P-4-2.

Beckman®
Scientific and Process Instruments Division
Beckman Instruments, Inc.
2500 Fullerton Road,
Fullerton, California

It's a Fact: The first oxygen analyzer to reach the moon may be a Beckman unit. During the Air Force's recent 7-day simulated flight to the moon, a Model F3 continuously measured the test chamber to help control the atmosphere.

PHOTO BY WILL CONNELL



COVER: *"Space Shuttlecock"—a painting by Edward Ryan appropriate to the Holiday Season.*

Astronautics

DECEMBER 1958

From the Editor's Desk

Designing and building a missile is one thing. Transporting, handling, testing, and launching it is something else again, as this issue of ASTRONAUTICS makes very clear.

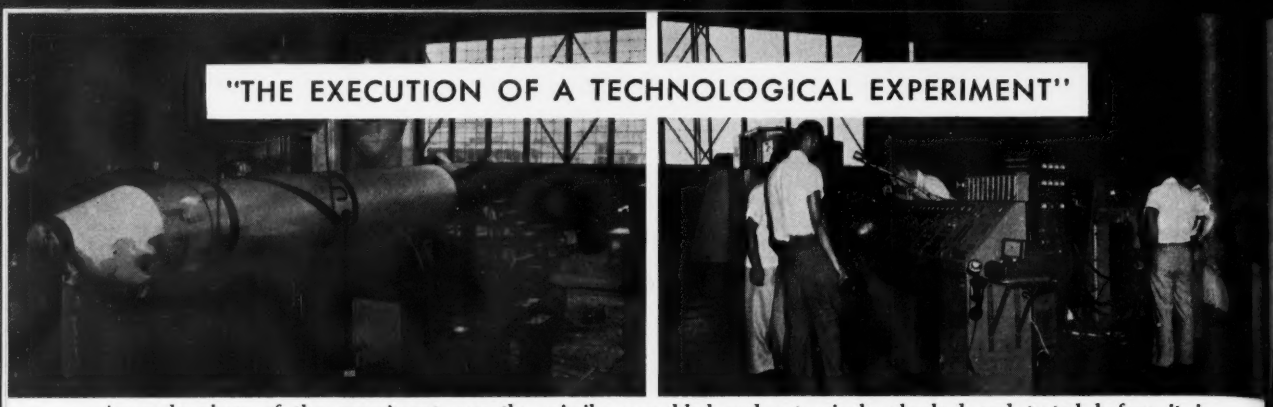
In the lead article, Kurt Debus, one of the country's top authorities in the field of launching of long-range missiles and space vehicles, demolishes a popular myth which has long plagued missile men—the common belief that success or failure can be measured in terms of whether or not an experimental vehicle successfully completes the powered portion of its flight during a test. In passing, Dr. Debus erases another folk hero, "the man who pushed the button."

Articles on the following pages cover the entire spectrum of handling, launching, and testing, from design of the equipment to firing of our largest vehicles. You'll find articles by experts from a dozen different companies and military establishments on such subjects as Atlas handling and launching, support systems for large engines, design criteria for ground support equipment, Polaris corrosion prevention and launching, etc.

Of special interest are two articles detailing the progress which has been made in the development of universal missile checkout and handling equipment.

All this, plus a rundown on some of the important technical papers presented at last month's 13th Annual ARS Meeting in New York, a special story on the X-15 and some major news features, as well as the usual monthly departments, makes this another outstanding issue.

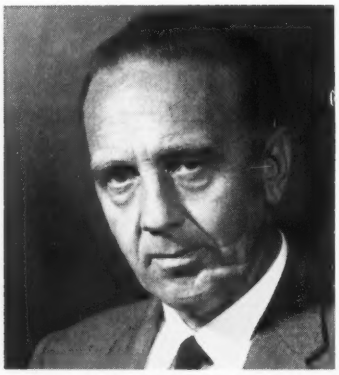
Irwin Hersey



An early phase of the experiment sees the missile assembled and extensively checked and tested before it is transported to the launch pad.

Experimental missile firings— A functional analysis

Launching is only one step—and by no means the last—in a technical experiment, and success or failure cannot be measured in terms of whether the vehicle aborts or completes powered flight in a test



As chief of the Missile Firing Laboratory at Redstone Arsenal, Kurt H. Debus has been responsible for the firing of several hundred R&D ballistic missiles. Born in Frankfurt, Germany, his background in the guided missile field goes back to 1940 when, as an assistant professor at the Technical Univ. in Darmstadt, Germany, he worked on development contracts for Peenemuende. He became chief test engineer at Peenemuende in 1944. In January, 1946, he became deputy branch chief for guidance and control of the Army Ordnance R&D program at Ft. Bliss, Tex., also serving as assistant technical director with responsibility for the development program of the Guided Missile Branch. Upon transfer of the project to Redstone in 1951, he assumed his present post.

By Kurt H. Debus

REDSTONE ARSENAL, HUNTSVILLE, ALA.

TO THE engineers, scientists and technicians engaged in research and development of ballistic missiles, and specifically in the firing phase at Cape Canaveral, Fla., the entire operation is a highly complex experiment involving the efforts of many people.

Their function is research, involving the use of long-range missiles to develop tactical weapon systems for the future or the application of existing hardware to test vehicles for satellites and space probes. Both activities are highly experimental in nature, but there seems to be a popular misconception triggered by the reporting of two incidents which were made to appear to be the criteria by which experimental success is measured.

This popular misconception may perhaps be explained by the sudden recognition late in 1957 that the space age had arrived. When this startling fact was recognized, the sharply inquisitive searchlights of public interest suddenly focused on the activity at Cape Canaveral. What was spotlighted by the "bird watchers" turned out to be the only portion of the test which was visible—the missile blasting away from the launch pad.

Public barometers of hope and confidence interpreted this event. When a missile exploded in the sky, a wave of mourning and disillusionment would sweep across the front pages of the newspapers, with even the stock market sometimes following suit. When a rocket appeared to last through its entire powered flight of 3 min, success for the system was reported.

This was needlessly wrong, because, just as an occasional missile

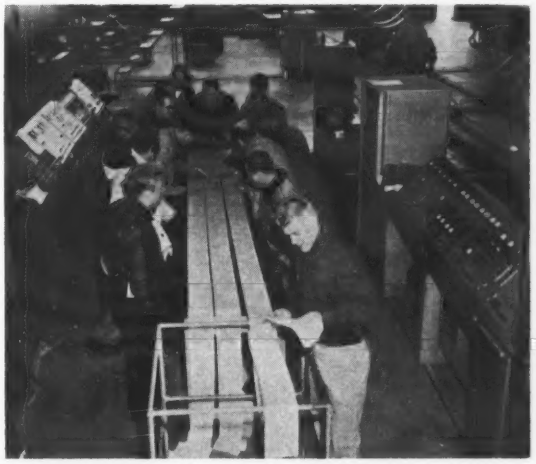
At the pad, the service tower (above left), a giant lab tool, serves to erect the vehicle—here, an Army Jupiter IRBM—and holds it in place for the flight phase of the experiment. In the blockhouse (center), no one person "pushes the button." Rather, automatic control equipment and many interlocking hands proceed with a complex countdown that continues after the vehicle leaves the pad (above right). Although this looks like the beginning of a perfect flight, the eye cannot gauge the success or failure of the experiment.

abort does not offer a valid indication of the development status of a missile system, neither does a complete flight provide positive proof of the quality of the system.

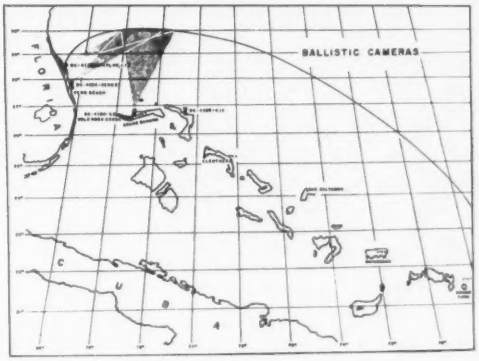
Later, the searchlights of public interest were beamed into the blockhouses, where the spectacular sight of instruments, panels, buttons and lights were summarized into the "pushbutton" and *the one* who pushed the button to cause the spectacular blastoff. Here, too, a closer look is required.

After Explorer I was launched, I was frequently asked the question: "Who pushed the button?" I have persistently refused to identify any single individual with this or any other launch success—or failure, for that matter—simply because the "Firing Command" push button does not fire the missile, nor does its operation carry any more significant responsibility than hundreds of other pre-launch relay or pushbutton operations.

"Firing Command" usually starts the first tank pressurization. There follow numerous other functional steps, of which the last are "Ignition" and "Main Stage." During the last 20 sec or so of the functional progression toward "Main Stage," sensing devices in both the missile and ground instrumentation carefully supervise internal proceedings within the missile, automatically freeing the path for the next step only after the preceding one is accomplished within present tolerances. If an erroneous or unsatisfactory condition is found to exist, the missile reverts to a harmless pre-launch condition.



Some measure of the experiment's success comes from data such as these telemetry records of the vehicle's flight performance.



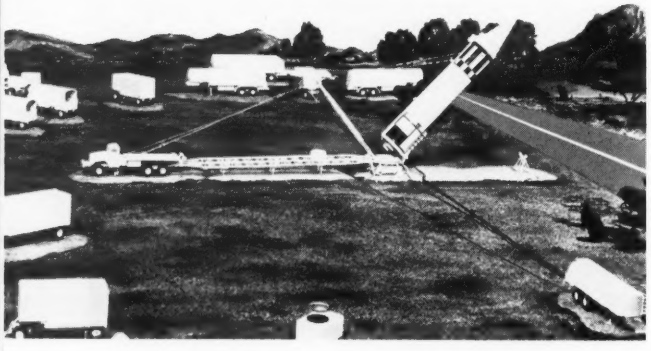
This optical tracking setup, stretching thousands of miles over the firing range, is a major element of the missile laboratory.

Last Step Is Automatic

"Main Stage"—the only irrevocable step for the ensuing expenditure of several hundred thousand or even several million dollars of taxpayers' money—is not trusted to a human operator under stress and thereby exposed to possible errors in communication, timing or judgment. This last step is executed by an ingenious automatic supervisor after it reassures itself that all is clear for "lift-off."

The act of firing an experimental missile is but one step, and by no means the last, in the execution

When a missile moves out of the lab into the field, it joins a cut-to-order "facility" of ground support equipment. Above, GSE for Jupiter integrated into AF ballistic missile operations. The petal-like structure folds up to form an all-weather enclosure for the missile. Below, a model of a fully mobile Jupiter system in the field.



of a technological experiment which previously has involved many fields of endeavor and separate development. This experiment is very much like any other experiment in a physics or chemical research laboratory, the only difference being in the size of the laboratory (possibly covering thousands of square miles), the magnitude and variety of support and test equipment, and the number of experimenters.

A hole-in-the-fence view of this experiment, then, has plagued the public, directing its attention to only a single incident in a massive whole.

Let's look a little further into the laboratory environment of this experiment, in the hope of viewing it whole, and, finally, in relation to the missile in the field.

As it approaches the summit of its life—the actual flight test—an experimental missile finds at the proving grounds a tailor-made berth, a place well prepared for its participation in the over-all experiment. This experiment will seek answers to specific questions. Facilities, instrumentation and men will have been selected to obtain these answers.

Facilities for the experiment must be developed parallel with the missile. For instance, buildings for pre-launch checks, calibration and assembly must be properly balanced, and must be equipped for adequate support in the form of laboratory space, mechanical and electrical workshops, spare parts, supplies and administration. These facilities, moreover, must be economical, yet adaptable to expanding programs.

In the launch areas, different types of launch pads, blockhouses and service structures are required. These massive service structures, 10 to 12 stories high, must be mobile and able to execute delicate and precise movements. At the same time, they must be sturdy enough to withstand winds up to 70 or 80 mph. They must also be adaptable for servicing missiles of different caliber, access areas and staging.

Reliable Power Supply Required

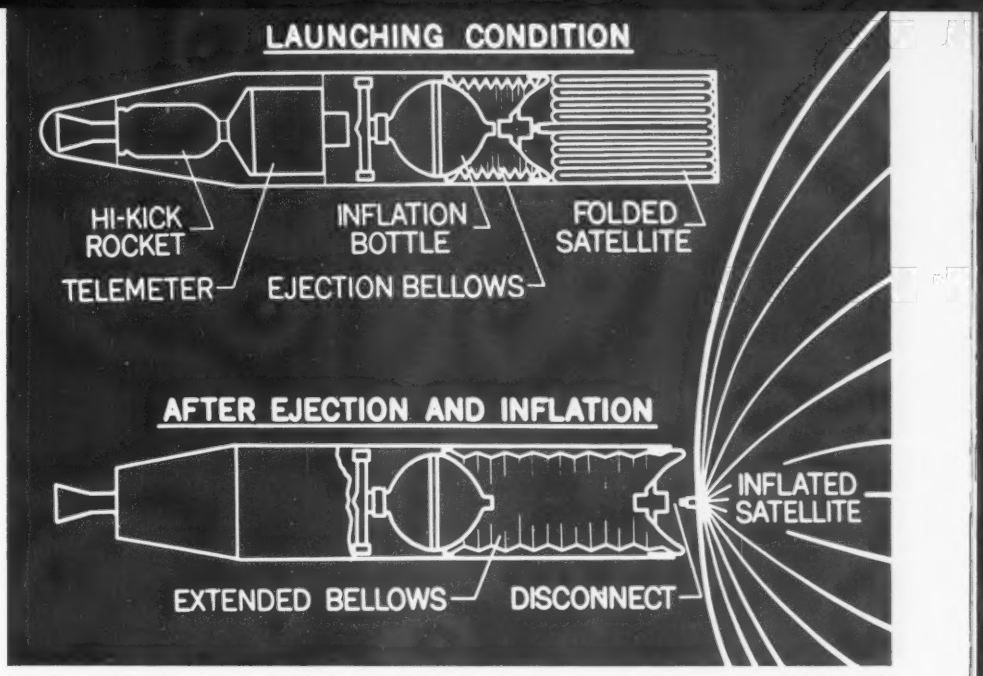
Subterranean rooms in the vicinity of launch pads must be provided to house electrical equipment which must be near the missile to keep voltage drops within tolerable limits. Adequate industrial power and precision-regulated scientific power of absolute reliability must be provided. Water and pumping equipment for fire fighting and for diluting great amounts of accidentally spilled missile fuel must be on a standby basis. Blockhouse instrumentation must be specifically adapted to any individual missile, yet must be suitable for expeditious conversion to different specifications as needed to make economical use of the investment.

These are but a few of the many items pertaining to support facilities. The hot test of the adequacy of such facilities begins with the arrival of the first missile at the proving grounds, when the facilities are as much under test as the missile proper.

Problems of varying magnitude confront the engineer when he designs the instrumentation for the experimental laboratory. Here, perhaps more than in any other area, it is mandatory that the advancing phases of the missile test program be accommodated by compatible measuring systems for tracking and the acquisition of data. Both require considerable time in design and construction, installation and testing.

At the time a new missile program is established, the missile system goes on the drawing board and the raw frame of the mission-assignment plan emerges. Program complexity increases progressively with the interest centered on powerplant performance, structural problems and staging techniques. (CONTINUED ON PAGE 52)

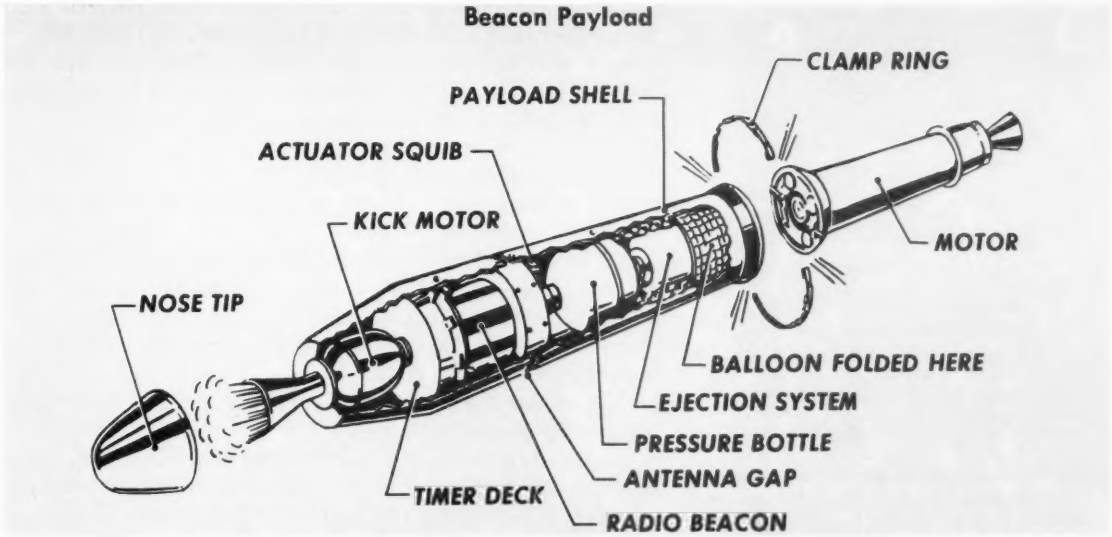
NASA
Satellite Beacon



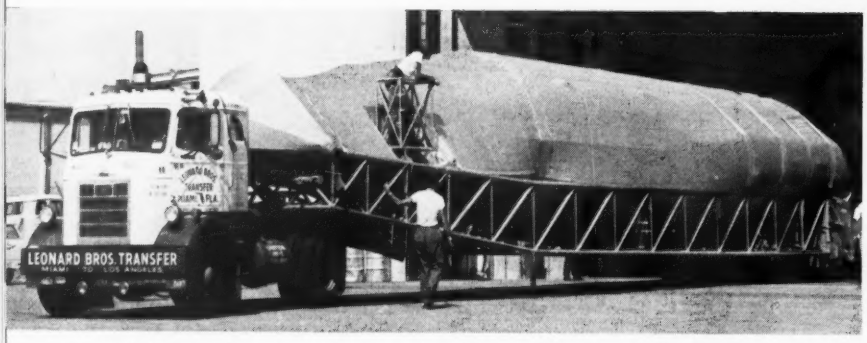
Top, how NASA's Beacon satellite is packed in its case, actually fifth stage of Jupiter-C vehicle. The 12-ft aluminized plastic balloon sits inside a 3-ft artillery shell type case 7 in. in diam. Above, how the balloon is inflated and ejected from the case.

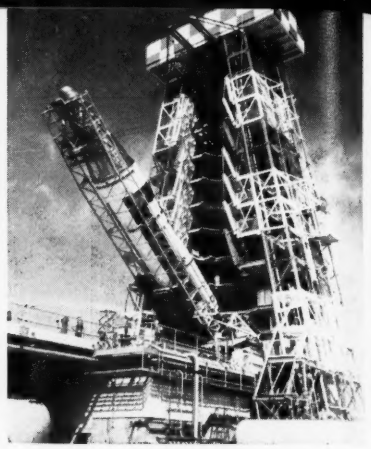
Space beacon

Here's how the Army hoped to put the 12-ft aluminized plastic balloon designed by NASA in orbit in Oct. 22 Jupiter-C firing



Cutaway drawing shows components of payload section. After payload nears orbital altitude, fourth-stage engine at right drops away and fifth-stage kick-motor fires, boosting payload into higher orbit as balloon is ejected and inflated from nitrogen pressure bottle. Payload shell carries radio transmitter for tracking purposes.





Atlas requires a minimum of handling because it is placed on a trailer at the factory, as shown (left), and not removed from the trailer bed until flight ready (right).

Atlas handling from factory to launch

A versatile trailer, mobile tower and a launcher with exacting mechanics handle the 65-ft Atlas body with precision and safety

By Chester J. Dunn

CONVAIR-ASTRONAUTICS, SAN DIEGO, CALIF.

Chester J. Dunn is senior project engineer for support systems at Convair-Astronautics, where he has been connected with the Atlas program since he joined the company in early 1957. After receiving his B.S. in aeronautical engineering in 1938, he was engaged in structural, hydraulic and mechanical design for several aircraft manufacturers. He has been in the guided missile field for 10 years, and, before joining Convair, held the positions of supervisor of missile design, chief of experimental design, and weapon system project engineer at Northrop Aircraft on Snark.

TO PROVIDE ground support equipment for any missile, two basic sets of criteria are necessary. First, the specific design characteristics of the missile which affect the ground support equipment must be known. Second, the "operational concept" of the weapon system—the how, when, where and under what conditions the system is to be used—must be established.

It is usually much easier to establish the basic characteristics of the missile, such as weight, size, load factors and launcher alignment, than it is to decide on the operational concept. Also, over a period of time during which experience is gained in using the system and during which national security requirements develop, the operational concept is more subject to change and development than the basic missile characteristics.

We are concerned here with the solutions to the handling and launching problem for the R&D test program on Atlas.

One of the earliest operational criteria was to have the smallest possible number of handling operations on the fully assembled Atlas missile between the final assembly sequence in the factory and the time it was erected on the launcher at the test site. The answer to this plan was a special trailer, which is shown loaded and ready for hauling in the first picture above and serving as a cradle to raise Atlas in the second.

The missile is put on this trailer during final assembly by an overhead crane in the factory, and it is not taken off until after the missile is erected in the flight-ready position. The complete booster section —that section of the missile containing the two booster engines and all equipment used only during boosted flight—may be replaced while the missile is on this trailer. In addition, all other functional

equipment on the missile is accessible for test, inspection and replacement. Only the nose cone is not assembled on the missile while it is on the trailer.

After completion at the factory, the missile is towed on the trailer by a standard AF tractor from San Diego to the Missile Test Center at Cape Canaveral, Fla. Existing road conditions require a 14-ft maximum clearance for bridges. The requirement to negotiate sharp turns during travel through towns with the trailer, which is 65 ft long, has led to the incorporation of steerable rear wheels similar to those on a hook-and-ladder fire truck. Trailer design permits road speeds up to 50 mph. For security reasons, the missile is shrouded with a tarpaulin-like cover during transportation.

On arrival at the test base, functional checkout of the missile systems can be performed on the trailer prior to erection for launching. Also, any necessary modification to or maintenance work on the missile or its components can be effected. This work is done in a factory-type building.

Steerable Wheels Facilitate Positioning

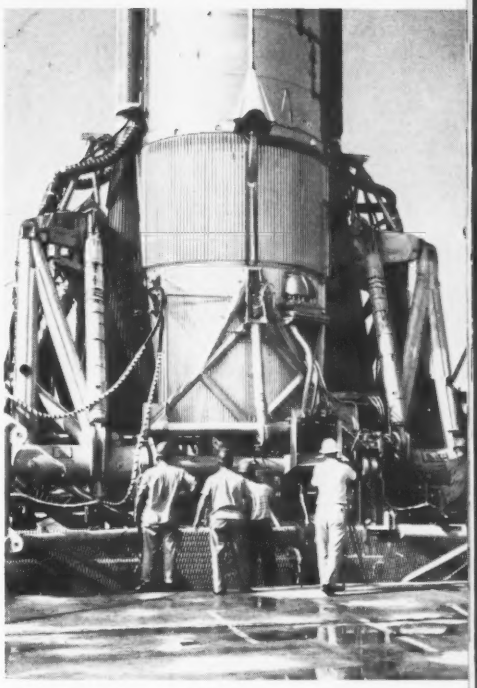
When the missile is ready for erection, the trailer is towed to the launching site and backed up to the launcher. Here again the steerable rear wheels facilitate accurate positioning of the missile with the launcher.

In normal position, the launcher is vertical. In order to receive the missile on the trailer, the launcher is rotated 90 deg to the horizontal position. The trailer is then backed into position and the missile locked to the launcher. At the same time, the rear of the trailer is attached to the same pivot point as the launcher through a member called the erector. At this time, the missile, launcher and trailer are free to rotate as one structural assembly, about the same pivot point, into the erect, ready-to-launch position. This erection is accomplished by cables attached to the front of the trailer from a winch at the top of the service tower. During erection, the trailer provides structural strength for the missile.

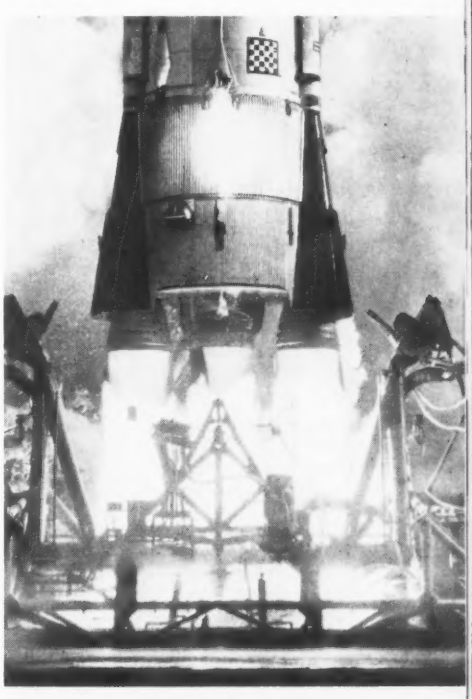
The service tower is a movable, structural steel tower with several functions. One function is to provide an aerial support point from which to erect the missile-trailer-launcher combination. It also provides a means of raising the nose cone from the ground and mating it with the erected missile. A series of platforms on the tower permits equipment at various heights on the missile to be reached easily during pre-launch operations. The inner lips of these platforms are retractable so that they can be moved out of the way when the missile is erected or when the tower is rolled away just before launching. The tower is designed to resist normally high winds, but, in case of a hurricane, it is tied down by cables.

After a missile is erected and necessary pre-launch operations completed, the tower platforms are retracted and the tower is rolled away from the missile. Because of launch site configuration, the tower first rolls onto a movable platform. Secured together, the platform and tower are then moved at right angles to the original line of travel for a distance of several hundred feet.

The launcher has the most rigid technical requirements of all the Atlas ground handling equipment. For example, it must be designed and positioned so that it will hold the missile within 1 deg of vertical. This is not because the missile could not be launched at angles greater than 1 deg of vertical; it is to (CONTINUED ON PAGE 86)



The launcher holds the missile within 1 deg of vertical under full thrust and then provides controlled lift-off by means of pneumatic cylinders.



The exhaust of the Atlas engines, as seen here, does not impinge directly on the launching structure when there are no cross winds to move the missile laterally.

ICBM launch control

Launch control and checkout equipment will play a decisive role in future nuclear wars. . .The Atlas control center described here is designed to insure "getting there fastest with the most missiles"

By Joseph E. Gallo

RADIO CORP. OF AMERICA, MOORESTOWN, N.J.

IN THE design of ICBM launch control and checkout equipment, one grim criterion predominates—that, in the event of war with a well-equipped enemy (and it is doubtful that we shall ever have any other kind), an ICBM base may have a life of less than an hour. Such bases are too large to be kept secret, and their potential retaliatory power makes them prime targets for an enemy's ICBM's. Therefore, our missile crews must be enabled to launch a maximum number of missiles in a short time, in order that the short life of an ICBM base will have maximum military use.

It's a chilling thought—that ICBM crews are potentially ground-based Kamikazes. But then, even the patriotic citizen will be denied his traditional sanctuary from which to exhort the troops—possibly science's most significant contribution to the cause of peace.

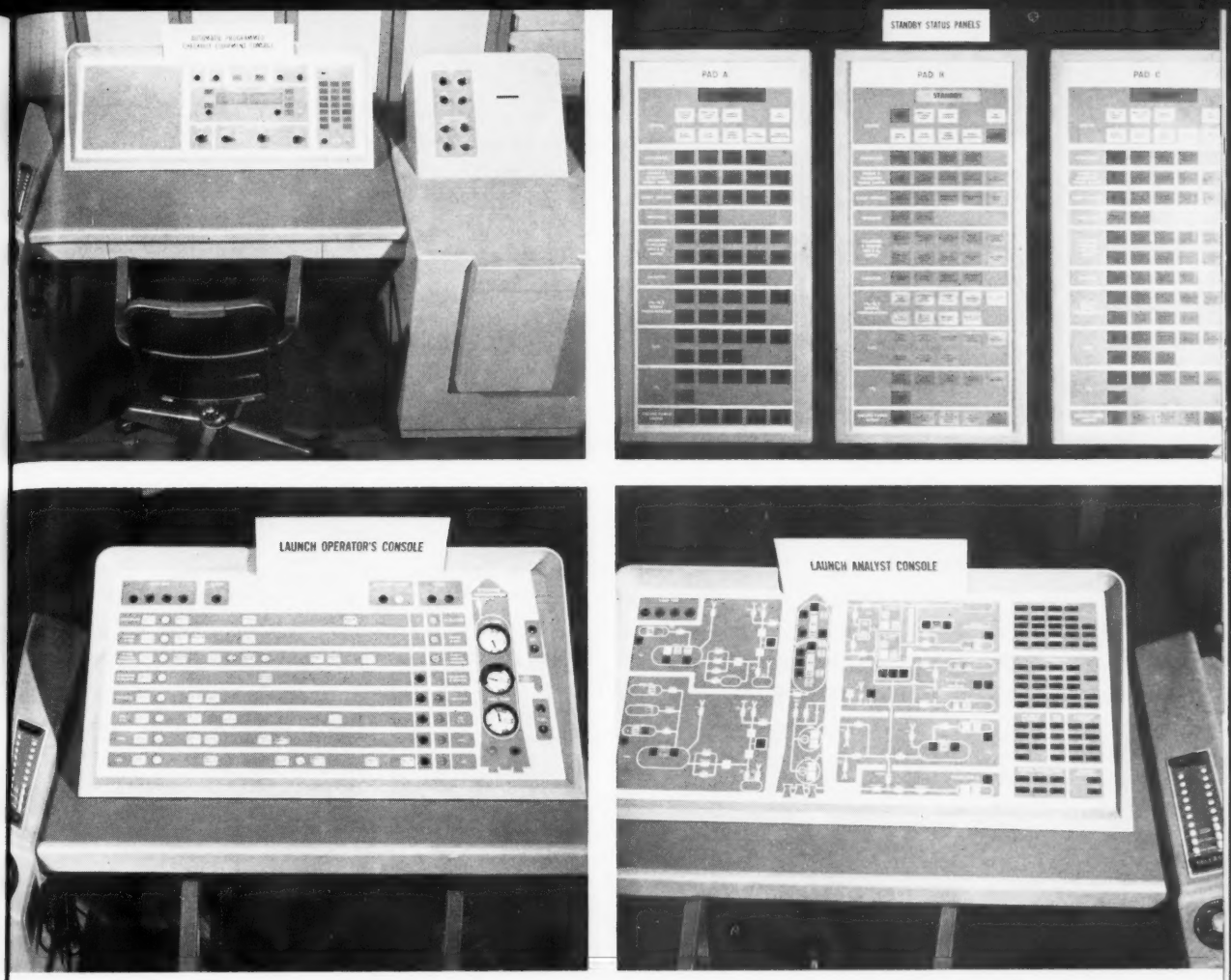
High reliability and rapidity of fire are obviously the necessary goals for the ICBM base. It is difficult to specify a reliability figure for the base other than 100 per cent, despite the many problems involved in attaining such a goal. A number can also be assigned for rapidity of fire. This number is based upon how far the enemy will be when he starts lobbing his ICBM's at our own ICBM bases. If he will keep his distance, say 5000 miles, and not be so unsporting as to go sneaking about offshore with missile-carrying submarines, we have about half an hour. Our absolute minimum rate of fire, then, is one missile in a half-hour. If we have 10 launch pads on our base, they obviously should be capable of launching all missiles within the same half-hour. There can, of course, be no maximum rate of fire.

Joseph E. Gallo is a Project Manager in RCA's Missile and Surface Radar Dept., responsible for Atlas launch control and weapon checkout R&D. Prior to joining RCA he was chief systems engineer in the development of flight simulators, and holds five patents in that field. In this capacity he developed and designed special purpose analog computers and associated circuitry for use in air navigation and spatial position computers for flight simulators. Before that, he did structural and electrical design of aircraft radar, communication and electrical installations. He received his B.S. in electrical engineering from New York Univ. and is a senior member of IRE.

Scheduled Goal Must be Attained

The "impossible" goal of 100 per cent reliability plus a high launching rate must be attained on schedule, too. This may lead to compromises of the moment, but the effort to attain the ideal cannot be relaxed. As anyone in the missile business can testify, designing missile systems to the naturally incompatible goals of quality and short schedules has all the satisfaction of R&D work, plus the exasperation of production engineering.

In any future nuclear war, the victory may well fall to the side that can successfully "launch the most missiles fastest." With the state of the missile art assumed equal on both sides, the advantage would



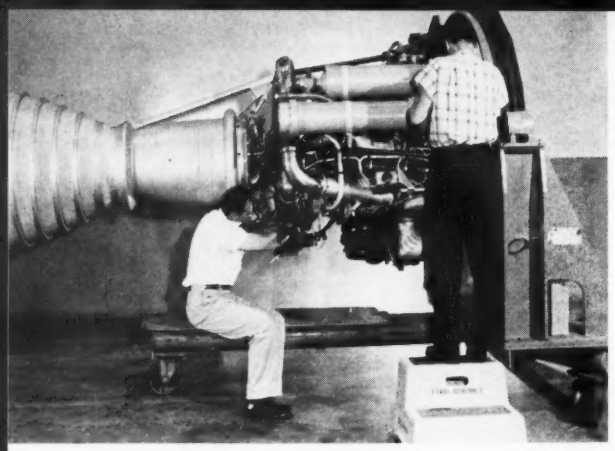
The focus for the Launch Control Center is this complex of consoles and panels: Top left, for automatic checkout of equipment; top right, for showing degree of missile readiness; and bottom two, which sit side by side on the same table, for controlling the missile launching operation and analyzing failures during countdown.

then go to the side with the better ground handling and launching equipment.

A typical ICBM launch control system of advanced design has been designed and built by RCA for the AF Atlas missile system under subcontract to Convair-Astronautics, the missile's builder. To present some idea of the size of the task, a typical Atlas complex requires over 200 cabinets of relay logic and newly developed transistorized digital and analog computer circuitry. Also, approximately 2000 cables are required (including waveguide and co-ax), and up to 78 conductor cables, with lengths as much as 1400 ft. Moreover, the information required to perform this task must be extracted from about half a dozen associate contractors while their designs are still in a state of flux. A year to do the job would have been too long, so this was truly an R&D job done at production speed.

The Atlas launch control system actually performs two distinct functions—checkout and launch. The checkout system, as the name implies, tests the missile and its ground support systems to determine operational readiness. The checkout system also checks the launch control system and its circuitry as an additional reliability safeguard. The Atlas utilizes an automatically programmed checkout system (APCHE). Decks of punched cards are fed to APCHE in order to determine checkout and test procedures. Missile systems are exercised as required for test, and the numerical results are evaluated to see that operation is within tolerance.

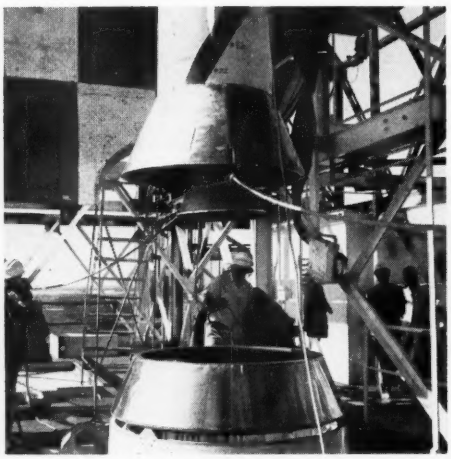
As still another step toward the ultimate in reliability, APCHE can also operate in a self-check mode, and would normally do so both before and after a missile checkout. For high accuracy, all comparator circuits are digital. All circuits are transistorized—again reliability. The speed with which the APCHE system (CONTINUED ON PAGE 96)

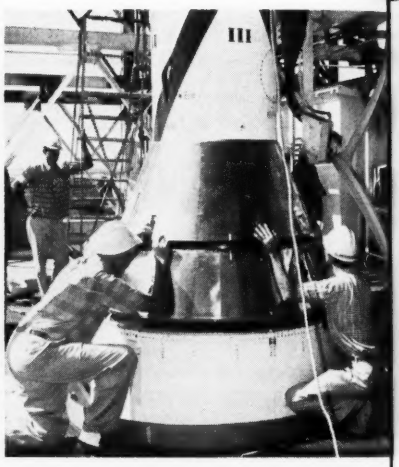


FIRST-STAGE ENGINE is readied for shipment from Rocketdyne's Neosho, Mo., plant. Douglas Thor was used as booster in Pioneer vehicle.

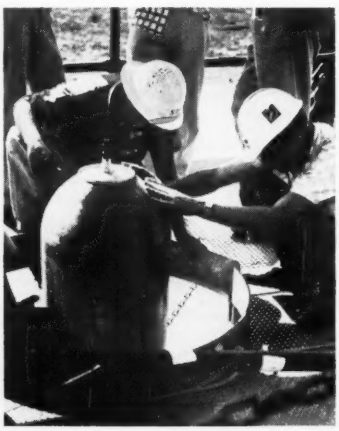
Moon probe launch: What it takes

This picture story offers some idea of the many steps that must be taken before firing button is pressed for a vehicle like Pioneer

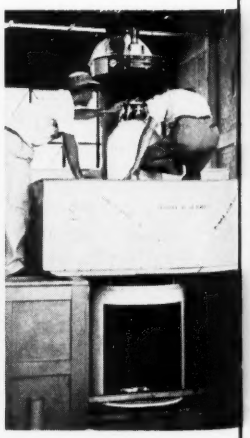




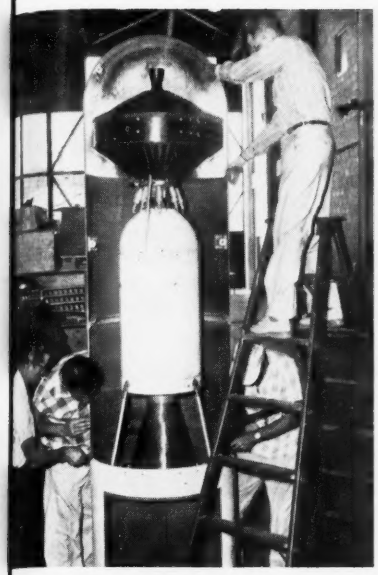
SECOND STAGE, modified version of Aerojet's Vanguard engine with eight spin rockets added, is mated to first stage, sitting in AF gantry at Canaveral.



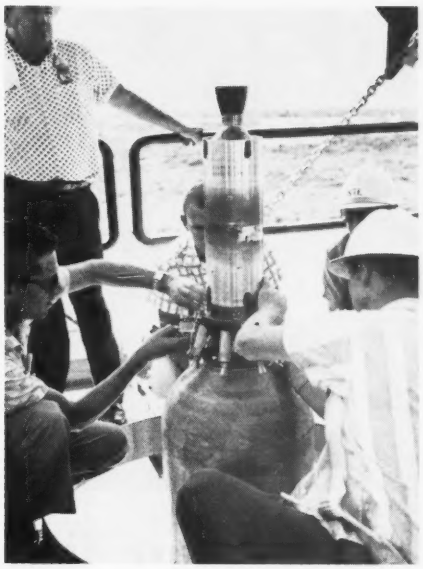
THIRD STAGE is installed and final adjustments made by technicians working on gantry.

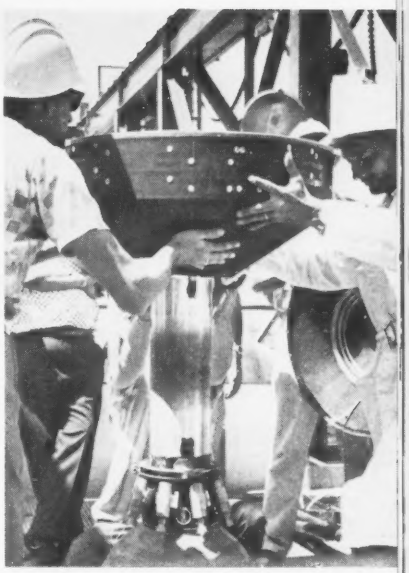


PAYLOAD undergoes pre-assembly inspection (left) and is tested for mating to terminal rocket (right).



NOSE COVERING for protection of third and fourth stages is checked out. Covering was jettisoned after first- and second-stage separation.





TERMINAL ASSEMBLY is fitted to third stage (left) and payload joined to fourth-stage engine (right).

VERNIER ROCKETS at base of instrumented payload are adjusted.

LAUNCH. Pioneer vehicle leaves Canaveral's Launch Pad 7A on start of 80,000-mile journey into space.

PIONEER VEHICLE SPECIFICATIONS

Height.....88.1 ft
Weight.....52 tons

First Stage

Standard Douglas Thor IRBM, with Rocketdyne liquid propellant engine
Weight.....100,000 lb
Thrust.....150,000 lb
Burning time.....157 sec

Second Stage

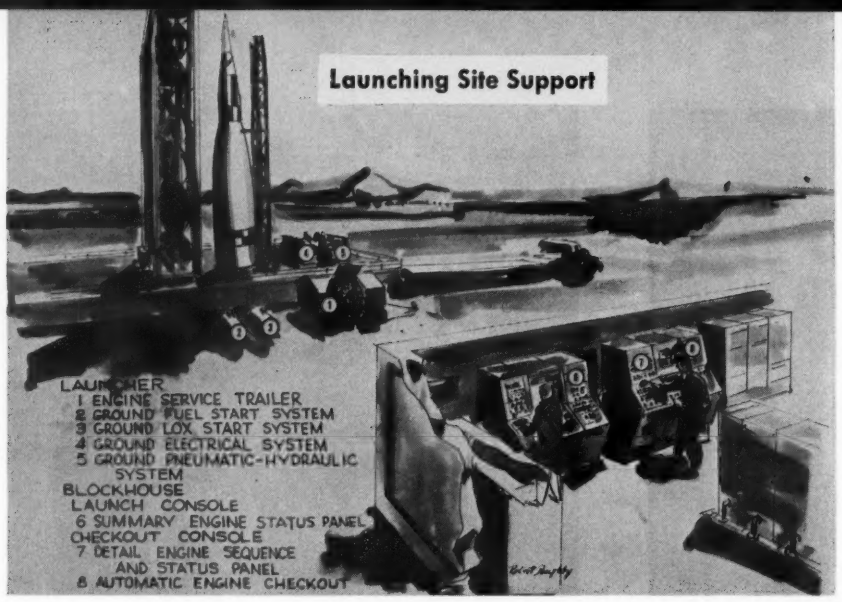
Modified Aerojet Vanguard AJ-10 liquid propellant engine, with eight spin rockets added
Weight.....4000 lb
Thrust.....7500 lb
Burning time.....120 sec

Third Stage

New Allegany Ballistics Lab ABL-248 solid propellant engine
Weight.....400 lb
Thrust.....2500 lb
Burning time.....$7\frac{1}{2}$ sec

Fourth Stage

Thiokol Falcon solid propellant engine, plus cluster of small Atlantic Research Corp. solid propellant vernier rockets, and Space Technology Labs instrument package
Weight.....85 lb, including 25 lb of instrumentation (batteries, telemetry system for measuring meteorite impacts, earth-moon magnetic field and interior temperature, and electronic scanning device)
Thrust.....3000 lb



Support systems for liquid engines

Powerplants used in our largest missiles and space vehicles require carefully engineered equipment for handling and testing in factories and assembly plants, in transit, at launchers, and in maintenance shops

Powel Brown is program engineer for ground support equipment at Rocketdyne. On graduating from Cornell Univ., he entered the Air Force during WW II, and was assigned to Wright Field, where he specialized in the development of aircraft engine suspension systems and the engineering evaluation of German turbojet and rocket engines. Leaving the service in 1946, he joined the Naval Air Missile Test Center, Pt. Mugu, where he worked for four years on development and operation of rocket engine test facilities, and then joined M.W. Kellogg to manage rocket engine development and production programs. He joined Rocketdyne in 1953.

By Powel Brown

ROCKETDYNE, DIV. OF NORTH AMERICAN, CANOGA PARK, CALIF.

A DOZEN ballistic test missiles and space vehicles will probably be lifted from the free world into space by large liquid propellant rocket engines this month. This impressive program depends, in part, upon the man-machine systems which effectively support rocket engines in factories and assembly plants, in transit, at launchers and in maintenance shops.

Ground support systems are developed and refined concurrently with engines and missiles, and with appropriate consideration for specific operational, logistic and maintenance concepts. It is significant that engines for all major liquid propellant programs are now supported in much the same manner, and that several opportunities for standardization among programs have emerged. Engine support is rapidly becoming a routine established practice, requiring relatively few equipment items and utilizing personnel with limited training and experience.

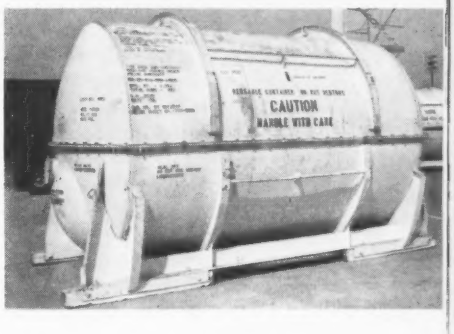
Requirements for engine support systems are influenced by many factors. Operational, logistic and maintenance concepts must be studied; functions must be assigned to men and machines; and specific items of equipment must be identified. This work is performed by the engine manufacturer in close cooperation with missile contractors and representatives from the using agency. The support system, when defined, must be reviewed for compatibility with other major portions of the weapon or space vehicle system.

System concepts, moreover, continue to be refined as missiles, engines and support are improved.

The design process begins with a detailed study of requirements. Then layouts are prepared for principal equipment and preliminary procedures for operating the equipment are drafted. This material is reviewed with contractors to assure compatibility with other portions of the complete system. Detailed designs are then prepared.

Most requirements for support equipment components can be met by commercially available items. Detail design effort is therefore concentrated upon system performance and optimizing arrangement and packaging. Some component design effort must be applied, of course, but this does not represent the main design workload.

Typical weapon and space vehicle programs must be supported by considerable component development. Environmental criteria are stringent and performance requirements severe. This is not true for most engine support equipment, which, experience shows, can be built largely from commercial components and put into service with a minimum of development work.



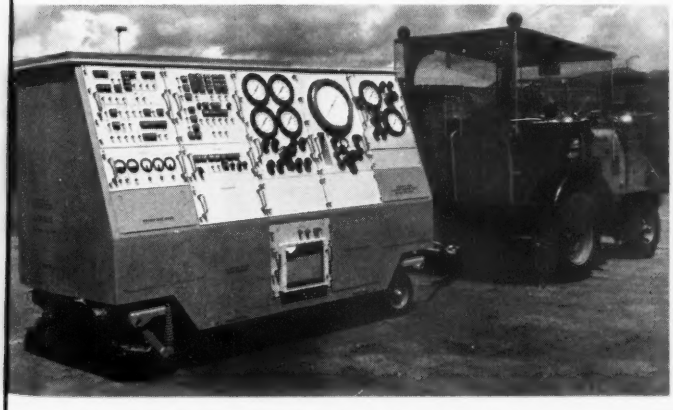
The light mobile trailer (above), with obvious weight advantage for air transport, is replacing the heavy steel tank (below) in shipping.

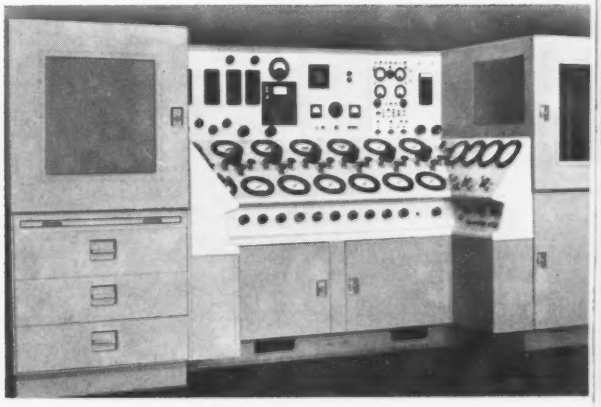
Early System Planning a Must

This equipment, however, must perform satisfactorily together with the missile proper, engines, trained personnel and other portions of the complete system. Difficulties are invariably encountered when this integration is first attempted. System planning and evaluation effort must be applied early to minimize these difficulties. Acceptance test programs, performed on first delivered items at the manufacturer's plant, demonstrate, satisfactory operation. Subsystems of several items are frequently assembled at this time to assure compatibility and to demonstrate proper interaction.

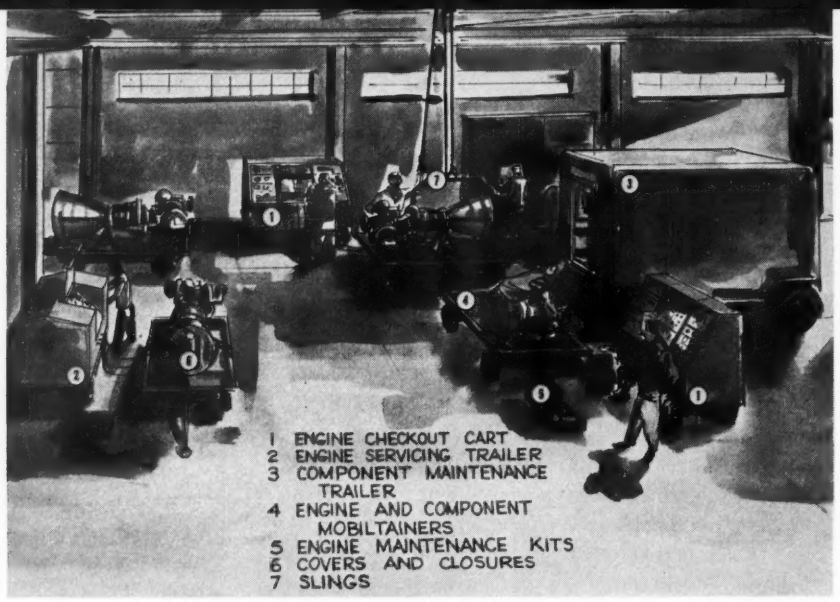
More extensive evaluation programs must also be conducted. Trained personnel must demonstrate the suitability of technical manuals, and operational and maintenance concepts must be evaluated and refined. Some of this work can be conducted by engine manufacturers prior to delivery of all portions of the system, but the final system acceptance test program is normally directed by the integrating contractor in accordance with requirements established by the customer.

Mobile units like this service the turbopump system of an engine.





Left, mobile units check out engines by testing components individually. Right, stands of this kind test repaired or replacement components functionally.



Engine Maintenance Shop

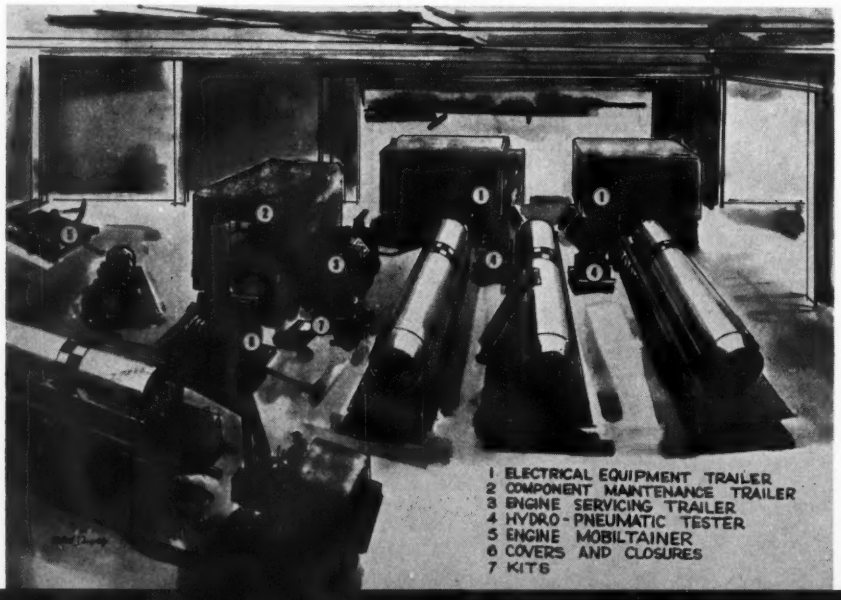
Several serious problems must be faced by the manufacturer. Equipment items incorporate electrical, hydraulic, pneumatic and complex mechanical systems. Extensive and versatile shop facilities are required for production of this equipment, and installation of inspection and test equipment is comparable to that required for engine checkout in the field.

Engine support items are not normally procured in quantity. Space vehicle systems do not require numerous support installations, and incremental provisioning procedures are usually applied for weapon systems to minimize obsolescence losses. The economic advantages of large-scale production can therefore not be exploited, and effort must be directed to minimize cost for production of limited quantities.

Rapid advances are being made in space vehicle technology, and effort is being applied continuously to incorporate these advances in existing systems wherever feasible. The benefits of system modernization, however, must be balanced against the costs of incorporating these changes in missiles, engines and support systems. Costs for revising tooling, spares inventories, technical manuals, training programs, etc., must all be considered. It is evident that a comprehensive analysis is required for even a slight change, and that each analysis must be conducted with full appreciation for the technical and logistic status of the entire program.

Even then, support equipment designs must be revised rapidly for compatibility with engine changes. These revisions are usually incorporated on the production line. (CONTINUED ON PAGE 62)

Missile Maintenance Shop



AF logistics for ballistic missiles

Need for operational readiness in minutes, not hours, and putting equipment in the field in a hurry has created many unique problems

By Col. Henry G. Macdonald (USAF)

AF JUPITER LIAISON OFFICE, ABMA, HUNTSVILLE, ALA.

LOGISTICS is the specialized mission of the AF Air Materiel Command. We buy, supply worldwide, and maintain some 1.5 million separate inventory items of air materiel. About two-thirds of the total AF budget is handled through AMC annually. An average figure in recent years is $9 billion. We hold in trust about $35 billion worth of the American people's total defense assets.

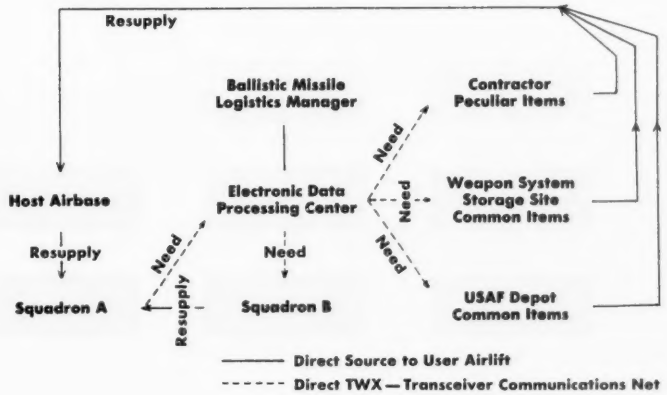
Our mission and our sole reason for existence as a command is to translate these resources into logistic support to AF operational units in an efficient and timely manner.

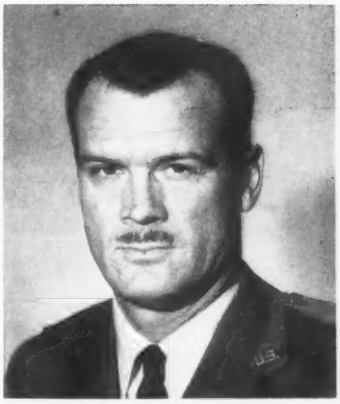
Since 1953, the nature of our job has been increasingly influenced by the advent of ballistic missiles. As the flow of dollars in support of ballistic missile programs has increased; and as the reliance by this nation for defense on these systems has increased, so have our interests and effort in developing a logistic system that can permit us to capitalize to a maximum on the inherent capabilities of the missile.

Looking through the glasses of the logistician, attention is focused immediately on the problems unique to logistic support of ballistic missiles. These problems result from three unique characteristics of the system. The first is simply that it is unmanned. We must learn to compensate for the man who is not there, for the human mind and judgment left behind on the ground.

The support of manned aircraft has always been complicated by the necessity for protecting frail man in an alien atmosphere. Now we see the other side of the picture–the (CONTINUED ON PAGE 99)

Logistic Support for Ballistic Missiles by the Single Manager

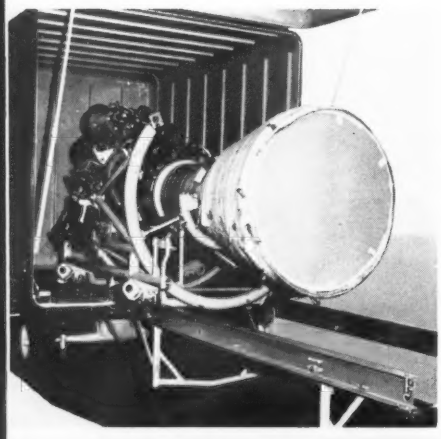




A graduate of the Univ. of Nevada, Col. Macdonald entered the service as a flying cadet in 1939 and saw action as a pilot and leader of a heavy bomber group in the European theatre throughout WW II. He was an instructor in strategy and tactics at the AF Tactical School at Tyndall Field, Fla., from 1946 to 1948, during which time he took an M.S. in industrial engineering at Columbia Univ., and was a staff member of the Munitions Board from 1948 to 1951. Graduating from the Air War College in 1952, he served for four years as deputy chief and then chief of the Industrial Resources Div. of AMC, Dayton. Late in 1956, he reported to AMC, Inglewood, as deputy chief of the Ballistic Missile Office, later becoming deputy director for ballistic missiles. Col. Macdonald was appointed chief of the Jupiter Liaison Office in March of this year.

Basic components of AF ballistic missile engine handling system. Left to right, workstand, transportation trailer, and Mobiltainers developed by Air Logistics Corp.

Universal engine handling equipment



Four basic pieces of equipment are all that's needed in transporting powerplants for all AF ballistic missiles

TWO YEARS ago, the AF Ballistic Missile Div. established a basic policy calling for all components of its coming missiles—Thor, Atlas, and Titan—to be air transportable, with backup by truck. The immediate problem for the AF was transporting, handling, and storing the engines which would power these missiles. This problem was complicated by the fact that the powerplants were large-volume, low-density, asymmetrical, and fragile units of various sizes, shapes, and construction.

The solution appeared to lie in a universal chassis which would accommodate both large and small beds and covers, the large one for the Titan booster and Thor primary engines, and the small one for Titan and Atlas sustainers and the Atlas booster and power packages.

Approach Grew Out of BMD-STL Studies

This approach grew out of studies by BMD and Space Technology Laboratories, and, carried out by Air Logistics Corp. of Pasadena, Calif. under a development contract, it led to the handling and transportation system shown on this page. This system and the studies preceding it were described at length by Lt. Col. Ray A. Wellman of BMD and Harold L. Straus of STL at the Fourth Joint Military-Industry Packaging and Material-Handling Symposium held in Washington, D.C., two months ago.

The system consists basically of large and small Mobiltainers which use the same undercarriage, a tire-mounted trailer, and a standard AF workstand. Special frames adapt the various propulsion components to these basic units. (CONTINUED ON PAGE 107)

How the equipment is used. Top to bottom: Thor engine being roll-transferred from workstand to Mobiltainer; Mobiltainer and transportation trailer on flat-bed truck; and Mobiltainer ready for loading on C-124.

Toward universal missile test systems

The time when you needed a separate tester for each module in a system, for each system and, often, for testing the tester, has given way to an era of the single unit of universal applicability

By Robert Gray

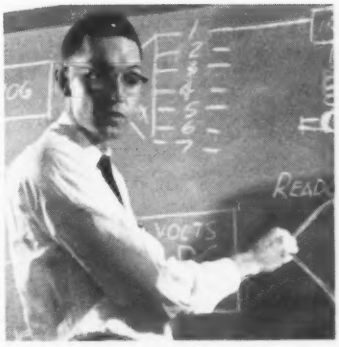
NORTRONICS DIVISION OF NORTHROP AIRCRAFT, INC., ANAHEIM, CALIF.

THREE years ago, Northrop Aircraft, Inc., of which Nortronics is now a corporate division, concluded, as a result of its experience on several types of pilotless aircraft, that system, subsystem, module and piece-part or component testing was a well-established branch of applied science. To be sure, it was a dynamic application, with new techniques cropping up each day. Much specialized test equipment was in use. The power supplies, stimulus generators and measurement instruments were universally applicable, but in attempting to simplify their specific use by medium skilled users, the engineers were integrating them into single-purpose units with single-point applicability.

Fortunately, we went through that phase rapidly. Each manufacturer sent a tester along for each module in a system, a tester for each system and, in the case of more complex applications, even a tester for the tester.

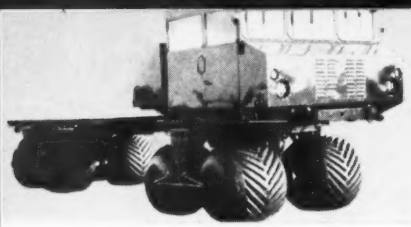
When Nortronics engineers finally started down the inevitable path of combining a multitude of single- or limited-purpose instruments and power supplies into a single complex of universal applicability, it proved an enlightening task. The word complex is very applicable because the result certainly was complex.

Fact One was immediately apparent. There was an obvious requirement for multipurpose instruments, power supplies and signal generators. Fact Two came right on the (CONTINUED ON PAGE 84)



Robert Gray is now chief of automatic test systems for Nortronics. His experience in the field of electrical and electronic support systems for missiles and aircraft goes all the way back to 1940, and his background in this area spans the era beginning with the Douglas DC-3, extending through the Snark and coming up to the Hawk and Nike-Hercules. His design philosophies in the application of automatic universal test equipment have been adopted by all branches of the Department of Defense.

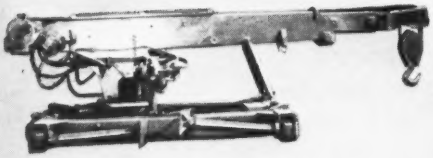
Programmed by punched tape, Nortronics Datico universal automatic checkout system can be used with different weapon systems with little more than a tape change.



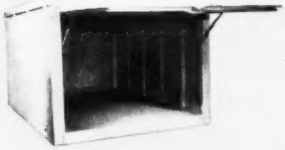
MM-1 TRUCK CHASSIS

TRANSLAUNCHER

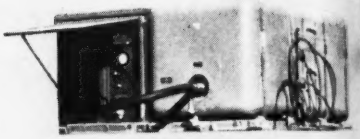
NOSE—BOOSTER PACK



CRANE



STORAGE PACK



FUEL PACK

GSE design criteria

Mace, one of the first major missile systems developed for practical field use, helped pioneer integrated ground support equipment

By L. W. Schopp and C. E. Fordham

GOODYEAR AIRCRAFT CORP., AKRON, OHIO

Schopp Fordham

L. W. Schopp, now head of project engineering on the TM-76A Mace ground support equipment program at Goodyear, has been associated with aircraft for 17 years. He is a graduate of the Univ. of Wisconsin with a B.S. in mechanical engineering. His co-author, C. E. Fordham, is systems engineer on the TM-76A program. He has been engaged in design and development of missile guidance and test equipment for the past eight years. He, too, is a graduate of the Univ. of Wisconsin, where he received an M.S. in electrical engineering.

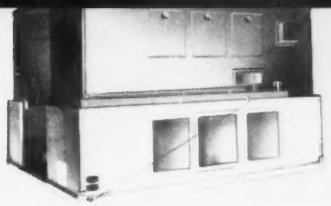
GROUND support equipment (GSE) has become an integral part of weapon system planning. The fact that an estimated $1.4 billion will be spent this fiscal year for GSE is an indication of its importance. Yet engineers have sometimes ignored ground support equipment in the early stages of weapon system development, thereby adversely affecting the design of both the missile and GSE.

It is now realized that the development of GSE should pace missile hardware for continuity. In addition, flexibility of design should be kept in mind, so that the same or modified equipment can be applicable to future missile models, as well as to other types of missiles.

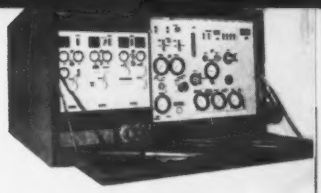
There are three distinct types of GSE: Equipment for handling, assembling and transporting the missile; for testing, preparing and firing it; and for communications between bases or sites and headquarters and for tracking purposes. Regardless of the type of missile, or the using military agency, these three types of GSE are required.

All three types of GSE should embody these design criteria: Reliability, safety of personnel, minimum logistics, speed of operation, all-weather operation, flexibility, low-skilled operators, standard parts, maintenance, low cost and light weight. Moreover, this list must be expanded to meet the particular needs of each missile—for instance, mobility and air transportability.

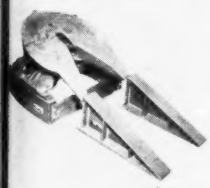
POWER PACK



TEST PACK



VAN PACK



FIFTH WHEEL

ADDS UP TO

MACE WEAPON SYSTEM

The TM-76A Mace weapon system, developed and produced by Goodyear for the Air Force, helped pioneer GSE planning for missiles, embodying these criteria more adequately than was previously possible for many missiles. This planning can be seen in Mace's system of building blocks, pictured on these pages. These blocks not only give the system flexibility in use and handling, but also can be used in other missile programs. The Mace system converges in one unified whole on the MM-1 Truck, which both transports the system in a unique manner and provides all prime power for it. Let's look at some of these blocks in more detail.

The MM-1 is a multipurpose, flat-bed, 8-ton, 8 x 8 truck designed specifically for the Mace program. It incorporates three major features:

1. Minimum logistical support. It is the only powered vehicle in the system, and transports all GSE, either singly or in combination, over all types of terrain. Its standard AF 250-hp air-cooled engine is the prime source of power for all but the communications equipment.
2. Mobility. Primarily because of the Terra-Tire, developed by Goodyear Tire and Rubber, the truck is capable of the highest degree of off-the-road mobility. Air pressure controls in the cab can be used to vary tire pressure while the truck is in motion. Low tire loading allows the truck to traverse any terrain—sand, marsh or snow. Maximum speed is 40 mph.
3. Air transportability. The vehicle was designed to be transported in an aircraft of the C-130 type. To make this possible, the cab of the truck was made collapsible.

The Translauncher, essentially a semitrailer towed by the MM-1 Truck, is used for transporting and zero-length launching the TM-76A Mace. It also serves as a platform for assembling the missile airframe and for preflight servicing and checking of the missile system. The Translauncher can be transported by rail, ship or aircraft of the C-130 type.

The nose- and booster-handling pack consists primarily of a bed on which are mounted a nose handling mechanism, booster handling equipment, stabilizing jacks and storage and handling equipment. The pack is mounted to the MM-1 Truck, and is used to assemble and transport the nose section, to transport the missile booster and to install these components on the missile.

Provides Power in One Compact Unit

The power pack, as the name implies, provides power from one compact unit for support of all but the communications equipment. Mounted on and deriving its prime power from the MM-1 Truck, the power pack furnishes 400-cps a.c., 60-cps a.c. and 28-volts d.c. power for all test packs, the calibration pack, and the missile, including engine start; furnishes hydraulic power required to level the Translauncher and to elevate the missile; is used to purge, fill and checkout the missile hydraulic-flight-control system; pumps air to cool the missile nose during nose test and checkout; and pumps fuel from the truck's fuel tank as the required flow and pressure to start the missile engine. The pack can be shipped by conventional truck, rail or C-119 type aircraft.

The pack housings, structurally very similar, contain all test, calibration and communications equipment, tools and maintenance spares necessary to support Mace in the field. The packs mount singly or in combination with (CONTINUED ON PAGE 78)

Welded steel structure at left supports umbilical mast loaded with sand bags in deflection test. Early testing of masts resulted in design changes.

Early testing means better ground support equipment

Producing the special load-testing equipment designed to demonstrate the capability of Thor launch mount and transporter-erector units approached design magnitude of some components of basic equipment

By Charles Johnson

ORDNANCE DIV., FOOD MACHINERY & CHEMICAL CORP., SAN JOSE, CALIF.

Charles Johnson, now project engineer for the Thor launch mount and transporter-erector, joined Food Machinery & Chemical Corp. in 1950 after receiving a degree in mechanical engineering from the Univ. of Santa Clara. His early assignments with the company included field testing and design engineering. In 1953, he became senior design engineer in charge of all military test programs undertaken by the company's Ordnance Div., and he later became project engineer for loader vehicles for the Army's Hawk anti-aircraft missile. He is a member of the Society of Automotive Engineers, as well as ARS.

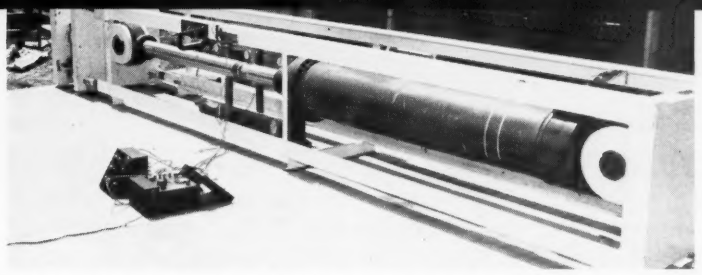
TEST PLANNING must begin when product design is approved, if effective missile ground support equipment is to be delivered on schedule. This is particularly true today, in the face of accelerated programs and resulting shrunken lead times.

All too often, test programs of this type are left to chance and, in fact, many items which should go through extensive testing are sometimes ignored completely until malfunctions and deficiencies are wistfully recorded in the field.

The need for accurate test planning made itself known early in the design of Thor missile ground support equipment by Food Machinery & Chemical Corp. engineers. Because of the design requirements, it was obvious that some method of demonstrating capabilities of the launch mount and transporter-erector units not only to erect the missile to firing position, but also to erect the missile load under "extreme wind conditions," would be necessary.

The ability to erect the missile to firing position could be demonstrated easily. However, demonstrating the ability of the equipment to erect in extreme winds was a different story. Since the size of the equipment precluded the use of wind tunnels or wind machines, it was obvious that special loading fixtures would have to be designed and manufactured to simulate static loads. Design engineers were therefore put to work early in the program so that necessary test equipment would be available for use on prototype mount and transporter units.

In many respects, design of this special load-testing equipment approached the design magnitude of some components of the basic equipment. The designers first considered the required extent of the simulated loads, the direction and various combinations of direc-



This simple test fixture was used for static test of Thor launcher's main hydraulic cylinder piston rod.

tions of application, and methods of reacting the resulting structural loads out into the ground.

It was obviously impractical to test all possible load combinations, since many were not limiting loads. In addition, the number of possible loading conditions would be too great to handle in the time allowed. The designers therefore worked closely with the stress groups in order to determine critical loading conditions and their points of application.

One piece of test equipment which was devised was a large welded structure which fits over the launch mount and is bolted to a specially prepared foundation integral with the launch mount foundation. Using this structure, it was possible to load the launch legs and duplicate the weight of the fueled missile with appropriate overload factors. In the same setup, shear and moments due to wind grade against the missile, the umbilical mast and launcher structures were applied by hydraulic cylinders and suspended weights. Blast loads, as well as forces in the launcher legs at missile lift-off, were simulated by utilizing a portion of this test structure.

Combined loads approaching half a million pounds had to be considered and applied to the launch mount in order to simulate the various loading conditions experienced during tactical use of the missile. The method of load application varied. In some cases, stacking of steel weights more nearly approximated actual loading conditions, while in other cases hydraulic jacks capable of exerting 100 tons of force were utilized.

Umbilical Mast Static Loading Test

Where it was necessary to simulate distributed load conditions, steel or lead weights and in some cases sand bags were used. One example, which utilized sand bags, was the static loading test of umbilical mast. The umbilical mast, incidentally, is that structure which connects the air conditioning and electrical lines to the upper section of the missile when it is vertical.

Since it was impossible to simulate wind requirements and accelerating loads encountered during retraction of this structure from its vertical position, a special fixture was built which permitted testing of the mast in a horizontal position. In loading the structure in this manner, it was necessary to take into account both weight and deflection.

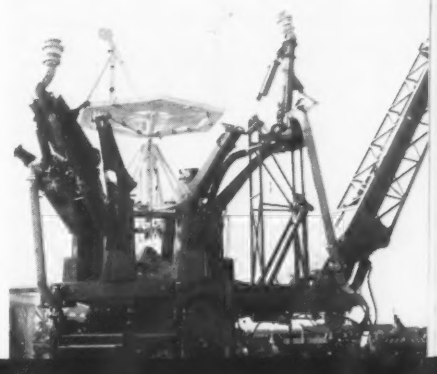
During actual operation the umbilical mast is relatively close to the missile, and design requirements stated that structural deflection under limit loads could not exceed 16 in. at the tip. In performing the load tests, it was found that stress level within the structure was very low but excessive deflection was occurring at the tip.

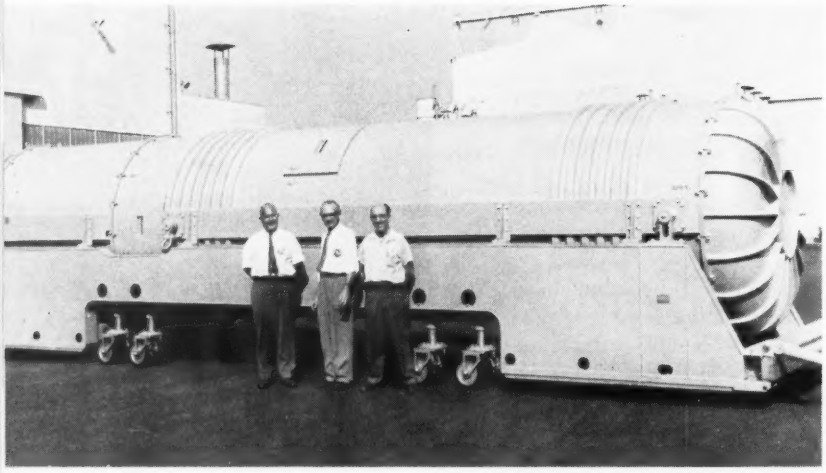
An analysis of the stress level within the (CONTINUED ON PAGE 53)

Test stand, built to mount over launcher, provides base from which forces up to half a million pounds could be exerted to simulate weight of fueled missile under varying wind conditions.

White painted test structure simulates base of Thor and provides mating surfaces for launcher legs and fuel and lox masts in cocked and ready-to-fire position.

Simulated lift-off, achieved as test structure rises, shows launcher legs and masts retracted to safe points beyond positions of possible missile drift.





Complete encapsulating container with some associated handling equipment.

Corrosion prevention for Polaris

Special protective finishes, corrosion-resistant materials and encapsulation provide capability for withstanding extended periods of constant readiness during storage or stowage without deterioration

By H. C. Slaughter

LOCKHEED MISSILE SYSTEMS DIV., SUNNYVALE, CALIF.

H. C. Slaughter is a graduate of the Carnegie Institute of Technology with a B.S. in chemical engineering. He is currently production engineering supervisor of materials and processes for Polaris at Lockheed Missile Systems Div. His previous experience includes production engineering materials and processes activity at the California and Georgia Divs. of Lockheed, and research in the field of corrosion while employed in the Chemical Metallurgy Div. of Alcoa Aluminum Research Laboratories in New Kensington, Pa. The author is a member of the National Assn. of Corrosion Engineers.

POLARIS, the U.S. Navy Bureau of Ordnance fleet ballistic missile, has confronted Lockheed engineers with a broader range of environmental conditions than appears to have been associated with previous missile systems. Furthermore, the deterrent and retaliatory nature of the intended Polaris mission demands a capability for withstanding extended periods of constant readiness during storage and stowage with no deterioration. The Lockheed Missile Systems Div., as Polaris missile systems manager, has considered effective corrosion prevention mandatory to the high degree of reliability inherent in Polaris design.

Corrosion mitigation has always involved the judicious application of materials, processes and techniques to retard or prevent undesirable chemical and electrochemical attack. The selection of corrosion-resistant and mutually compatible materials, the elimination of areas of potential moisture and contaminant entrapment by proper design, the application of protective coatings and finishes, and the control of environment by encapsulation, are commonly employed.

In this respect, corrosion prevention for Polaris and its support elements is not significantly different than for any other product designed and manufactured for naval use. However, the scope of the problem has been extended by the presence of sensitive elec-

tronic gear, as well as use of some materials of lower corrosion resistance to meet extremely high performance requirements.

This means that the following elements of the system require effective corrosion protection:

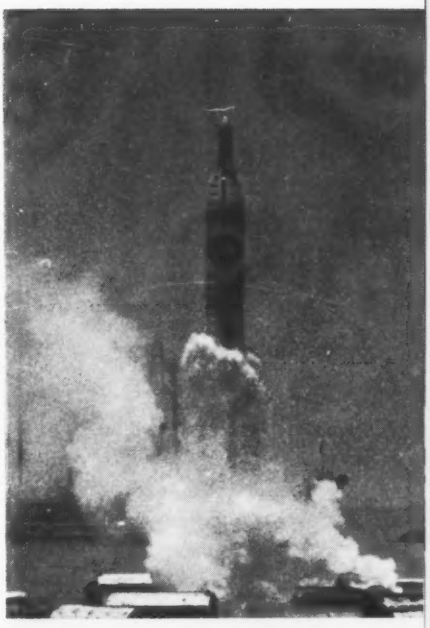
1. The missile itself, from initial fabrication and assembly to firing or technical obsolescence.

2. Automatic checkout and readiness equipment (ACRE), throughout the period of fleet use of Polaris as a weapon.

3. Handling and storage containers which are used for transport and storage of major Polaris elements prior to shipboard installation.

The flow chart on this page illustrates the salient features of Polaris evolution and operation from basic fabrication items through completion of the mission. Suffice to say that deterioration by corrosive attack must be prevented throughout this entire sequence up to the instant of firing.

The illustration at top right serves to demonstrate the unique nature of some of the environmetal conditions encountered with Polaris. Considering the change in pressure experienced with underwater launchings, as well as the subsequent aerodynamic heating encountered in portions of the trajectory, it becomes apparent, for example, that a sealing compound employed in caulking seams and joints in safeguarding against corrosive attack must also be resistant to high pressures and temperatures.



Preliminary underwater-launching test suggests unusual environmental conditions Polaris encounters.

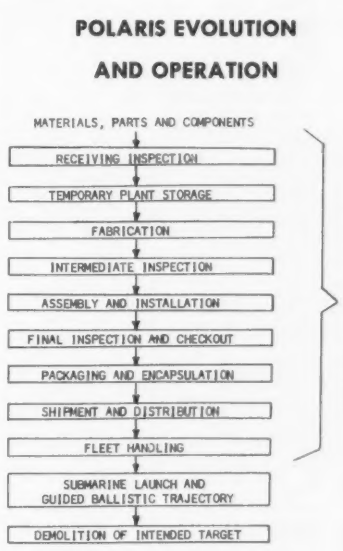
Encapsulation Approach Employed

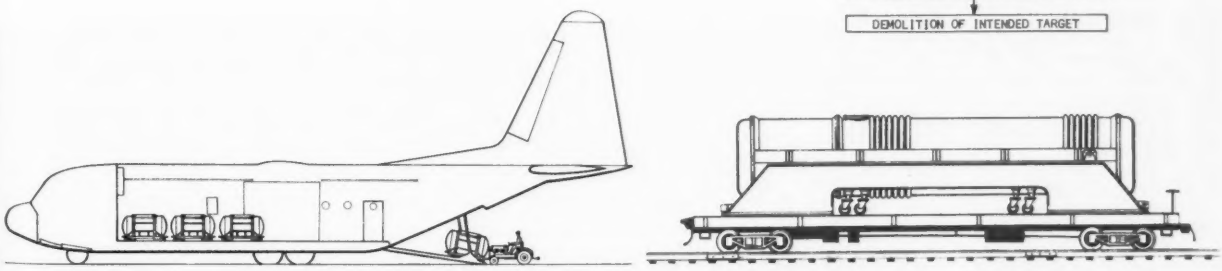
The encapsulation approach which has been adapted to provide controlled environment for shipping, handling and storage is shown on page 38. Here, desiccants and proper sealing play a major role in maintaining the moisture content of the encapsulated environment below the threshold at which corrosive attack can occur.

The following examples are typical of the specific protective measures employed for the flight article:

1. In design, the selection and juxtapositioning of metallic materials has been carried out in accordance with the definition of dissimilar metals provided in MS-33586 (Metals, Definition of Dissimilar).

2. Purchasing specifications provide for such protective measures as moisture-barrier packaging paper, polyethylene-bag packaging and corrosion-preventive oils for materials, (CONTINUED ON PAGE 64)





Polaris weapon system components in sealed containers are transportable in C-130 (left), while missile itself, in a sealed container, can be transported by rail (right).

The Polaris launching system

"Pop-up" concept, dictated by need for combining launcher and storage magazine in submarine firings, more than satisfies space and weight, safety, environment, handling, and heat, blast, and noise requirements

By Capt. Dennett K. Ela (USN)

NAVY BUREAU OF ORDNANCE, WASHINGTON, D.C.

Capt. Dennett K. Ela has since March, 1956, been assigned to the Navy BuOrd Special Projects Office, with primary duties in the field of Polaris launching and handling. A 1938 Annapolis graduate, he was assigned to sea duty until May, 1941, when he was ordered to MIT for post-graduate training in naval architecture and marine engineering, receiving his M.S. in 1944. His Navy career includes assignments with the Naval Shipyard in Boston; with the Naval Technical Mission in Europe; with the Naval Forces Western Pacific (7th Fleet); and with the Naval Reserve Training Publications Project. In 1949, he was assigned to the Contract Design Branch of the Bureau of Ships, heading up projects including guided missile ship design, carrier conversion, and new carrier construction. Prior to joining the Special Projects Office, he was Deputy Chief of the Development Div., Armed Forces Special Weapons Project, Sandia Base, Albuquerque, N.M.

WHILE many aspects of launching and handling of the Polaris missile must, of course, be generalized to avoid classified details, the significant features of major interest may be reviewed. Specifically, material relating to system dimensions, test objectives, and test data must be omitted. However, it is possible to discuss the interesting factors underlying the selection of a launching method and significant design problems.

The Special Projects Office, set up to plan and produce a fleet ballistic missile system, has played an outstanding role in the critical process of decision-making so necessary to a minimum time-scale program. The staff has evaluated the problems and the risk, decided on a single course of action, and allowed little deviation to the very many attractive avenues of development that occur.

The merits of a diversified approach have been extolled in engineering development in the same manner as investment in stocks to minimize losses, but it does not maximize the return. The special project is now far enough downstream with sufficient development success to know that the problems remaining can be solved, and that the quickest path to success has been chosen. In the specific case of the launching subsystem, the decision process resulted in the selection of a method unique in most respects. As we shall see, the calculated risk was not great.

At program inception, there are two possible techniques for getting on with the conceptual engineering. One may be to blanket the industry with solicitation for studies and proposals, but this implies some sort of specification for guidance at a time when such a specification does not exist. The other technique is to carry the conceptual work out within the staff.

The latter was more characteristic of our operation in launching. This has a singular advantage, assuming a mature group of engineers is available, in that, as operational requirements are defined, the concepts under study can be adjusted. Operational research takes time, and the answers are seldom crystal clear because needs must be tempered with the physical limitations of the delivery system and the cost.

In the case of the Polaris system, we needed to know the follow-

"If the magazine was a tube, the problem of guiding the catapulted missile could be effectively solved."

ing requirements from operations research to arrive at a launching concept:

1. *Ship type.* Surface ships of combatant type or merchantmen; submarines in surfaced, submerged, or both conditions.

2. *Rate of fire.* Time to first launch and each succeeding shot or salvo.

3. *Numbers.* Missiles per ship unit.

4. *Environment.* Polar or equatorial operations.

If a launching system is incapable of a high rate of fire, then perhaps fewer numbers of missiles per ship and greater numbers of ships are required. A different type ship may be more capable. We must therefore take into consideration the fact that there may be some trade-offs in the requirements, depending on the launching concept, not to mention other subsystems, such as the missile itself or fire control.

Must Fit Both Ship and Missile

If the above interplay appears complex, bear in mind that this is only half the problem. The launcher system represents the compatibility link between ship and missile; it must fit both. The demands of the delivery system (the ship) and the missile then impose another series of trade-offs between launching concept and the following:

1. *Space and weight.* Confined areas and stability restrict ship installations.

2. *Auxiliary equipment and services.* Details that often wag the dog.

3. *Storage and handling.* When there are more missiles than launchers.

4. *Environment.* Protection of missile from unwanted characteristics found aboard.

5. *Heat, blast, and noise.* Protection of the ship from unwanted missile characteristics.

6. *Safety.* Against loss of crew or ship.

Surprisingly, or perhaps even trivially, it turns out for Polaris that a launching concept with the optimum fit to all the above criteria is about what would have developed starting with the premise of optimum launching characteristics and then testing for fit with system requirements.

Perhaps we have dwelled overlong on some fairly obvious ground rules for conceptual decisions. The elaboration is deliberate, because we have reviewed proposal after proposal of pet schemes which failed in consideration of one or more of these criteria. A bit of reflection makes it apparent that, except for ship motion, the same (CONTINUED ON PAGE 97)

ASM handling and launching

Here's how Bell engineers went about the job of solving ground checkout, communication, tracking and safety problems in developmental flight testing of the Rascal air-to-surface missile

By Kenneth L. Levin and David Feld

BELL AIRCRAFT CORP., BUFFALO, N.Y.

Levin Feld

Kenneth L. Levin is manager of the Avionics Dept. of Bell Aircraft's Space Flight and Missile Div. After receiving a B.S. in E.E. from the Univ. of Michigan in 1940, he was employed for five years by Colonial Radio Corp. on the development of specialized test equipment. The next three years he spent at R. Wurlitzer developing electronic musical instruments. Since 1948 he has been with Bell, where he has held positions on the field-test and project staffs for the Shrike and Rascal programs.

David Feld of Bell Aircraft's Rockets Div. is technically responsible for the Rascal propulsion system. A mechanical engineer, he has spent the last 15 years in the design, test and development of reciprocating engines and liquid propellant rocket propulsion systems. Prior to joining Bell in 1950, he spent two and one-half years with Martin as a propulsion engineer on the Viking program. Both programs have afforded him the opportunity of working very closely in the establishment and conduct of field-test operations.

BESIDES the usual problems of handling and launching, an air-to-surface missile brings special problems of communication and countdown, safety for launching aircraft and crew, and high potential failure owing to inability to "hold" for minor repairs during a countdown.

Let's look at some of these problems for an air-to-surface missile (ASM) in the context of a development test program, as seen from experience gained at Bell Aircraft in the launching of the Rascal missile and its precursor, Shrike, from B-50's, B-36's and B-47's. Over 1500 accident-free flights were conducted with these aircraft during the development of Shrike and Rascal at Holloman Air Development Center, N. M.

To begin with, we know the objectives of the flight-test portion of a development program are: To demonstrate the practicality of the design; to integrate modifications; and to integrate missile, carrier, ground support equipment and checkout procedures for operational capability.

Problems of handling and launching begin with flight and instrumentation planning, when test objectives are defined and considerable instrumentation is allocated. At this time, although appreciating that space is at a premium in a missile, the engineer must think of providing generously for instruments in the missile. This is one place where redundancy can be tolerated to assure that adequate data will be obtained in a minimum number of launchings.

Scheduling of Operational Equipment

Operational ground support equipment and operating procedures (technical orders) should be scheduled during the latter phase of the development program, for it is at this stage that hardware and procedures are sufficiently jelled and enough "bugs" are worked out to warrant the use of "go-no-go" checkout and handling equipment. This is also the phase at which it is advantageous to introduce military personnel to handling and checkout procedures.

Problems of launching proper are not much different for an ASM like Rascal than for surface-launched missiles (including IRBM's and ICBM's) from the standpoint of detailed subsystem

checkout, long countdowns and long hours to meet flight schedules. But the ASM brings special problems, such as establishing and maintaining communications with a countdown that is taking place thousands of feet in the air at several hundred miles an hour. A problem unique to Rascal was the requirement that its prime powerplant operate while the missile was attached to the aircraft. This allowed system checkout prior to missile release, but at the same time necessitated a complex electronic monitoring system to assure safety of the aircraft and its crew.

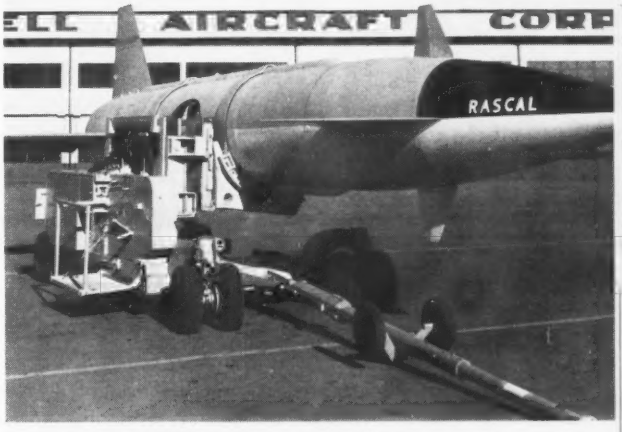
Finally, and far from least important, is the high mission abort rate due to inability to "hold" for minor repairs during a countdown. This makes high component reliability a must prior to initiating the flight test program. Complete functional testing, including environmental testing, is the best guarantee of minimum component failures in flight.

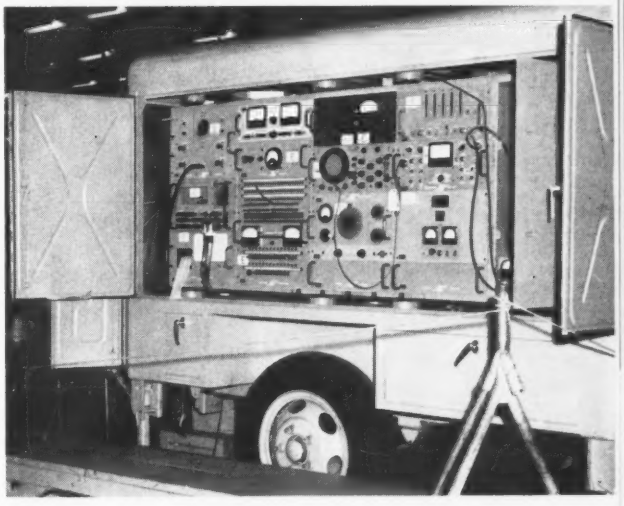
Certain features of Rascal, moreover, necessitated the design of unique ground-handling equipment. As can be seen in the top picture at right, Rascal is carried on a pylon protruding from the aircraft fuselage, and oriented at a 13-deg roll angle. Positioning this 46-ft missile in roll, fore and aft, right and left, and pitch and yaw so that the fore-and-aft launch hooks engage simultaneously, made necessary the complex missile-handling carriage shown in the second picture.

Has Trouble-Shooting Capability

Similar complexities were prevalent in the requirements for Rascal checkout equipment. Preflight checks were conducted with the launching console hook up, making static firing on the ground feasible prior to a launching. The console was thus provided with trouble-shooting capabilities, which would be impractical in a flight console due to weight and space limitations. Checkout equipment had to simulate the launching console and be thorough enough to substitute for a static-firing test. The mated checks between carrier and missile are of the "go-no-go" type. The bottom photo on this page shows the checkout trailer, which is mobile. The checkout equipment is versatile enough to be invaluable in trouble-shooting during the mated compatibility checks.

Rascal, like many large missiles, required subsystems flexible enough to be checked out in any sequence. A failure in one subsystem, then, did not stop the checking of the missile, but merely shifted the sequence of the check. Of course, procedures are generally written for a given sequence of checks; and when deviations occur from the normal sequence, special procedures must be written for the missile to assure (CONTINUED ON PAGE 76)





Rascal, the country's largest current air-to-surface missile, rides from a two-lug pylon on a B-47 (top). Positioning the 46-ft Rascal exactly on this pylon, which is tilted to give the missile a 13-deg roll angle, required the design of a complex handling rig (center). Bottom picture shows mobile ground checkout equipment, which can substitute, in its functions, for static test on the ground before a flight.

Astronautics at the Statler

17 technical sessions at ARS 13th Annual Meeting in New York range all the way from propellants and structures to U.S. space capability

By Irwin Hersey

THE WIDE scope embraced by the AMERICAN ROCKET SOCIETY's present technical activities was never more clearly demonstrated than in last month's 13th Annual Meeting at the Hotel Statler in New York.

The 17 Technical Sessions at the meeting ranged all the way from such subjects as propellants and structures to a Secret session on U.S. space capability, and in passing touched on such diverse areas as sealed cabins, nuclear propulsion, magnetohydrodynamics, and research rocket vehicles. Other sessions dealt with combustion, psychophysiology, ramjets and mixed cycle engines, utility and law in space flight, space flight operations, guidance, missile controls, and large liquid and solid rockets.

Student papers presented at the Second Annual ARS Eastern Regional Student Conference on the final day of the meeting touched many of the same bases.

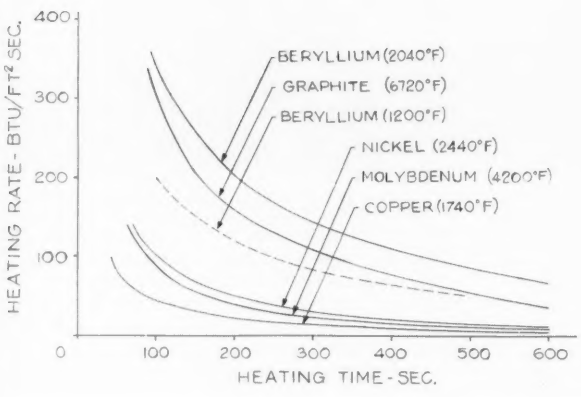
While it would obviously be impossible to present a complete rundown on the more than 50 papers presented in the nonclassified sessions, some idea as to the breadth of the subjects which came under discussion can be gathered by taking a brief look at just a few of them.

• One of the more startling suggestions at the meeting came in a paper by Russell M. Kulsrud of Princeton Univ.'s Project Matterhorn on "General Behavior of Hydromagnetic Fluids" (ARS Preprint No. 705-58). Kulsrud noted that MHD may make the science-fiction writer's dream of an invisible force field which can deflect enemy missiles and other concrete objects a reality.

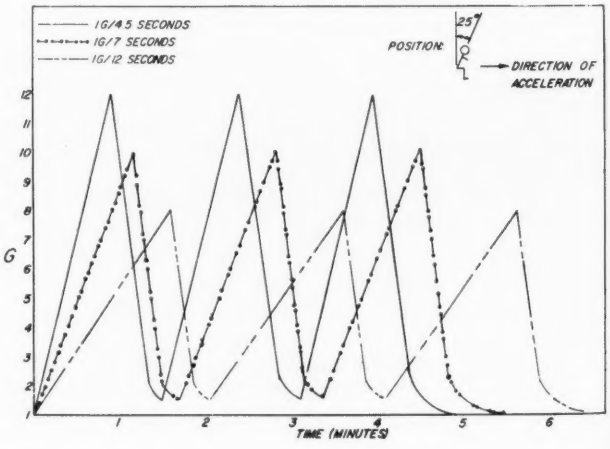
While Kulsrud pointed out that the object on which the force field acts must be highly conducting, he noted that in such cases it has already been shown that it is possible not only to deflect, but also to handle, tangible objects with intangible magnetic fields.

• Two Solar Aircraft Co. engineers stated in a paper on "Brazed Sandwich Structures for Missiles and Space Vehicles" (ARS 730-58) that welding

Heat Sink Capabilities (Maximum Potential)



Three-Stage Rocket Acceleration Patterns for Orbital Velocity Tolerable to Man



and brazing operation might be performed in space by focusing of the sun's radiant energy. Richard S. Mueller and George D. Cremer commented that the natural environment of space should insure fast heating and immaculate high-vacuum metallurgical conditions of a type difficult to achieve here on earth. This, they noted, would facilitate construction and repair of vehicles in space.

• ARS President-Elect John P. Stapp of Wright-Patterson AFB told the Society that man is capable of enduring the accelerations anticipated in attaining orbital or escape velocities with present three-stage rocket systems, as well as the prolonged exposure to low acceleration required for re-entry.

However, he added in his paper on "Accelerations of Space Flight" (ARS 700-58), man will scarcely enjoy either of these ordeals, nor is he likely to, until the design and operation of space vehicles advances to the point of complying with parameters of human effectiveness through the use of long-duration, low-thrust propulsion systems with low g factors, rather than imposing on survival limits.

• F. L. van der Wal and W. D. Young of Space Technology Laboratories, revealed in the first public report on the AF Mouse-in-Able program (ARS 715-58) that two mice flown in biological experiments tied in with the AF re-entry test program last July returned to Earth safely from a higher altitude (approximately 1400 statute miles) than that reached by any other living organism after experiencing conditions similar to those associated with satellite re-entry.

Telemetry data from the two flights indicate that takeoff conditions were not severe enough to produce any violent or continuing response from the mice, and no evidence of distress due to weightlessness was noted in either flight. In the experiment, the mice were weightless for longer periods than any animal other than Laika.

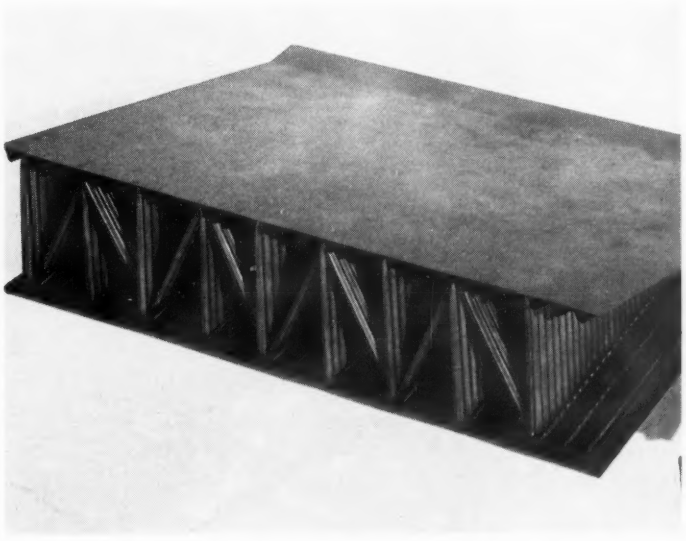
The paper noted that there is every reason to believe the mice could have been recovered alive after their flights if the nose cones had been retrieved, since instrumentation indicated they were alive when they hit the water.

• The nuclear propulsion session produced a number of interesting papers, among them a full-scale report on Project Rover, the nuclear rocket propulsion program at Los Alamos Scientific Laboratory, by Raemer E. Schreiber of Los Alamos. The paper (ARS 689-58) indicated that the Kiwi-A reactor, slated for testing in the near future at the AEC Jackass Flats, Nev., proving grounds, will explore new areas of temperature and power density.

In other parts of the program, Dr. Schreiber noted, research is going forward in development of new materials and new concepts for the conversion of nuclear energy, from which a practical propulsion system can be developed. He indicated that very attractive performances result from the use of liquid and gaseous reaction systems if they can be made to work.

• Morton Camac of Avco Research Laboratories offered a possible solution to the problem of reducing flight time in moving satellites utilizing electrical propulsion system and orbiting in the Earth's gravitational field from one orbit to another, or in navigating between orbits for rendezvous or intercept purposes. Dr. Camac suggested (in ARS 721-58) that stored electrical power be used for such flights.

• In a paper on "Struc- (CONTINUED ON PAGE 53)



Welding and brazing of metal sandwich structures of this type might be performed in space by focusing of the sun's radiant energy, two Solar Aircraft engineers noted.

Three-quarter front (at right) and rear (far right) views of X-15 show design details: Stubby wings, side fairings on fuselage which house propellant and control lines, wedge-shaped vertical tail, mounting of two 4-barrel rocket engines which will be used in initial flights.

The X-15: Mach 7 aircraft

North American's rocket research plane, slated to take to the air in February, will answer questions about flight conditions beyond the earth's atmosphere, re-entry and man's reaction to space flight

THE X-15 rollout in mid-October marked the public debut of a vehicle which will provide the answers to some of the most important questions in the minds of astronautical scientists and engineers—questions about flight conditions outside the earth's atmosphere, re-entry, and human reactions to such factors as weightlessness and high acceleration.

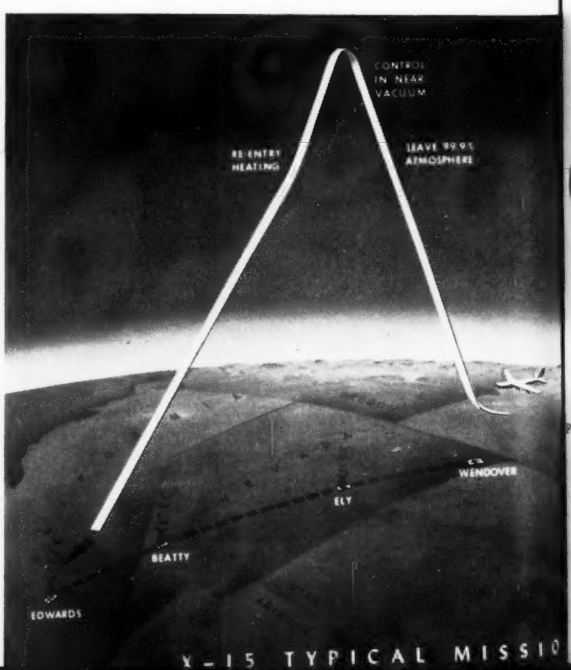
For North American Aviation's hypersonic rocket-powered research vehicle—publicly attributed with Mach 3-4 capability at 100-mile altitudes but privately believed capable of achieving Mach 7 on the basis of wind tunnel tests at the AF Arnold Engineering Development Center—is actually a flying laboratory designed to probe the approaches to manned flight in outer space.

Uses 1300 Lb of Instrumentation

To answer these questions, the X-15 is equipped with over 1300 lb of instrumentation, including approximately 600 temperature and 140 pressure pick-ups; equipment to measure pilot reaction to controls, control position and air vehicle response; and strain gauges to measure structural and aerodynamic loads on specific surface areas of the ship.

This instrumentation is designed to provide data about four different areas of research interest. These are:

1. Flight conditions beyond the earth's atmosphere, aerodynamic heating and the effect of high temperatures on structural components.
2. Exit from and entry into the earth's atmosphere.
3. Control requirements at the low pressures found at extremely high altitudes.



Anthropomorphic dummy, wearing AF pressurization suit to be used by X-15 pilot, ready for engineering test of supersonic ejection seat. Note foot clamps, arm guards and seat fins.

4. Human reactions to such factors as weightlessness, acceleration and deceleration.

To achieve these objectives, the combined talents of more than 300 firms throughout the country have been utilized in building the ship, and what began as a joint study between NASA (then NACA) the Air Force and the Navy to develop specifications for an extremely high-altitude, high-speed aircraft, has turned into a nationwide project.

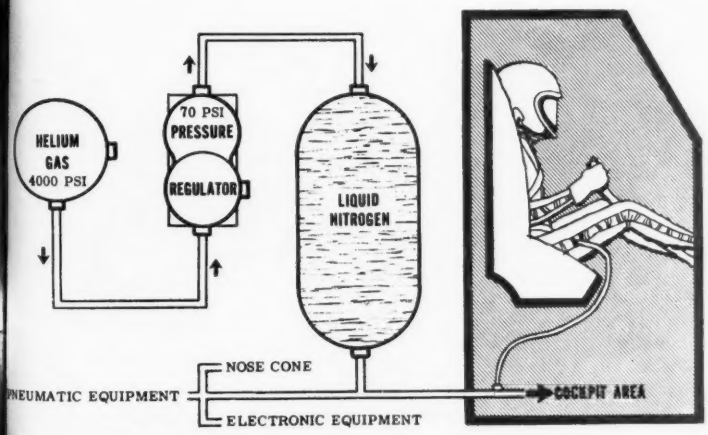
North American's Los Angeles Div. is prime contractor for development and manufacture of the X-15. Reaction Motors Div. of Thiokol will supply the liquid rocket engine which will power the ship, with GE's Accessory Engine Div. building the auxiliary power units. Garrett Corp. supplies the liquid nitrogen cooling and pressurization system, while David Clark Co. is producing the AF pressurization suit for use by the X-15's pilots.

International Nickel Co. developed a new nickel alloy, Inconel-X, used for the ship's external skin. Bell Aircraft makes the rockets used for control outside the atmosphere, while Sperry Gyroscope developed the in-flight electronic indicator system, which transmits speed, altitude and angle-of-attack data to the pilot, and recording apparatus. Lear, Inc., provided a special three-axis indicator for the pilot which shows the ship's attitude in relation to earth.

Posed Manufacturing Problems

Building a ship capable of withstanding the extremely high and low temperatures the X-15 will encounter in flight posed many problems in manufacturing. For example, while Inconel-X can stand up under temperatures ranging from —300 to 1200 F, new welding and brazing techniques had to be developed to adapt it for production.

Also, auxiliary power (CONTINUED ON PAGE 94)



How liquid nitrogen in Garrett Corp. pressurization and air conditioning system will be directed to vital areas in the ship.

X-15 SPECIFICATIONS

Length 50 ft
Height (over-all) 13 ft
Wingspan 22 ft
Gross weight at launching 31,275 lb
Powerplant
- Basic 1 XLR-99 RMI liquid rocket engine
- Interim 2 RMI XLR-11-5 liquid rocket engines

Wings
- Sweptback C/4 25 deg
- 200 sq ft in area
- Box-type construction—main spar
- No movable surfaces
- Inconel-X (welded) throughout solid nose section, providing heat sink

Landing gear
- Dual-wheel nose wheel
- Steel skids for main gear

Missile market

ROBERT H. KENMORE, *Financial Editor*

AS THIS can, I suppose, be considered the "Christmas Issue" of the magazine, this column wishes to extend to all investors a Very Merry Christmas. As taxpayers and voters, you may be waiting for merrier times in the future, but as investors you surely have something to celebrate about in this Holiday season. A glance to the right tells the over-all story, of course, but conceals even such success stories as Chance Vought, Emerson Electric, Litton Industries and Thiokol—all five having doubled in price in the last twelve months. Raytheon has tripled! Many others have outperformed the 50 per cent increase of the Missile Index as a whole. The primary story that this market action has imparted can, I think, be summarized in the following way: As I pointed out in a recent article in "The Commercial & Financial Chronicle" (reprints of which will be gladly sent to those of you requesting a copy) missiles are here to stay, and Washington press announcements about economies are just political expediencies from a vote-conscious Administration. Although company managements have too much at stake to ever permit themselves to abandon their nervousness about these political pronouncements, investors should once and for all decide to ignore all such talk of trying to stem the inevitable tide of tremendously increasing defense budgets. If peace of mind in today's world means large inflationary deficits, then the most brilliant economists or administrators are not going to be able to talk their country men out of having them.

December is tax-selling month for investors, and two aspects of this phenomenon are worth discussing in this column. It is amazing how many investors still fail to realize that "tax dollars" are just as real as those shown by a bank balance. To disregard the tax results of any given security transaction is as shortsighted as never to invest at all. The main points to keep in mind are:

1. Both short-term *and* long-term gains and losses are taken 100 per cent into account, and can be fully offset against each other.

2. If the net result is a long-term capital gain, however, only *half* of it is reported as income. (Long-term is anything held over six months.)

3. While December 31, 1958 is the last business day to sell a security and establish a loss, December 24 is the last day you can sell to establish a gain to report on your 1957 tax return.

4. A maximum of $1000 of security losses can be offset against ordinary income from any other source in any one year.

5. Losses can be carried forward for five years, however, and can be offset in unlimited amounts against security profits in future years, in addition to reducing ordinary income by $1000 in each succeeding year.

6. Although most missile securities have risen substantially in price during the past few years, some of them are still selling below their 1955–57 highs (i.e., Boeing, Thompson Products, General Precision Equipment) and will be tax-selling targets this month. As a result, buying opportunities will develop in these companies' securities as their price will be artificially depressed in the latter part of December.

7. If you sell a security to register a gain, you must wait 30 days before repurchasing the same security.

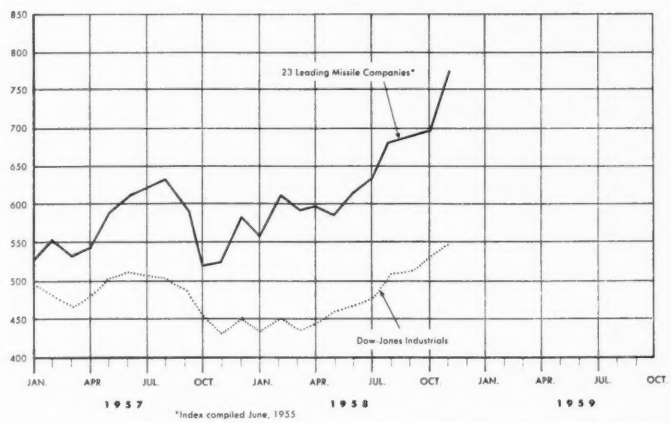
The rest of this month's column is devoted to an analysis of a security that seems to be outstandingly undervalued in these days of generally high prices. Inasmuch as the market is finally beginning to recognize this fact, limit orders below the market are suggested so that the stock can be purchased on normal reactions.

The first fact to clearly establish about General Tire & Rubber is that there is $^{8}/_{10}$ of a share of Aerojet-General behind each share of stock. This means that, as this column is being written, the market is literally *giving away* one-half of the company, since General is selling at just about $^{8}/_{10}$ of the price of Aerojet. This seems to be giving away an awful lot, since General's non-Aerojet sales total approximately $200 million a year. The market has, of course, been discounting fiscal 1958's poor earnings results ($0.91 for the nine months ending August 31, as against $1.61 for the same period in the previous year), but with next year's earnings expected to rise to the $2.50 level, with the strong growth pattern evidenced by Aerojet, and with management's demonstrated flexibility and foresight, the long-term investor can currently buy into leadership in the missile-rocket field at a substantial discount by purchasing General Tire common stock.

Very little needs to be said about Aerojet (estimated sales of $200 million and earnings over $1 per share in fiscal 1958), the acknowledged leader among the "true" missile companies. While it is true that its earnings are being appraised generously by conservative market terms, the security has not appreciated in value in the last fifteen months. Any over-valuation here is in the past, as the company's operating results are living up to the high expectations held by earlier

(CONTINUED ON PAGE 80)

THE MARKET AT A GLANCE



*Index compiled June, 1955

	Nov. 1958	Oct. 1958	% Change	Nov. 1957	% Change
Dow-Jones Industrials	543	527	+3.0	435	+24.8
Missile Index	775	694	+11.7	524	+47.9

When your problem is FLUID CONTROL specify WHITTAKER

PERFORMANCE REQUIREMENTS

For a pressure actuated valve, controlling flow of helium for LOX tank pressure regulation:

Ambient Temperature
−65°F to +120°F

Temperature Shock
−260°F for 5 seconds, then to +400° in 25 seconds

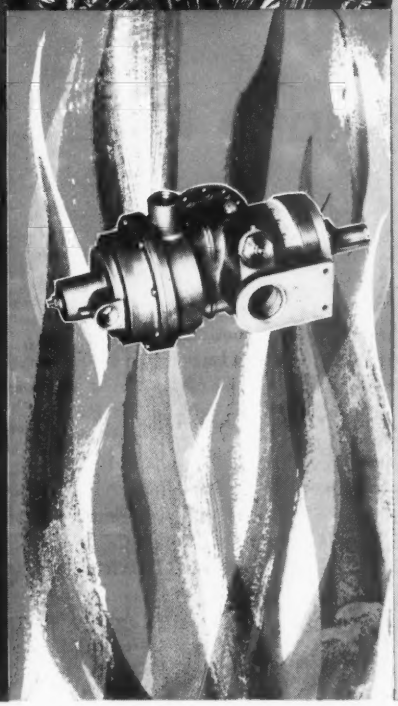
Pressure Shock
0 to 3000 psi in ½ second

Control Tolerance
26 psig + zero, − 1.3 psi, in small ullage

Response Time
Zero to rated flow in ½ second.

Design considerations: Rate of flow of helium is fixed by rate of evacuation of LOX tank; friction in all metering elements must be minimal at all temperatures; chatter must be prevented despite pressure shock; response must be rapid despite long signal sensing lines.

Results: A valve (P/N 121485) meeting all of these requirements is now operational—another Whittaker contribution to America's missile program.



WHITTAKER CONTROLS OFFERS THE INDUSTRY'S TOP FACILITIES FOR:

Research and Development
Prototype Production
Performance Testing
Environmental Testing
Field Testing
Quantity Manufacture
Field Servicing

These facilities, together with the industry's most resourceful and competent engineering and technical personnel, are at your disposal, to solve your most exacting hydraulic, pneumatic, and fuel valve and control problems.

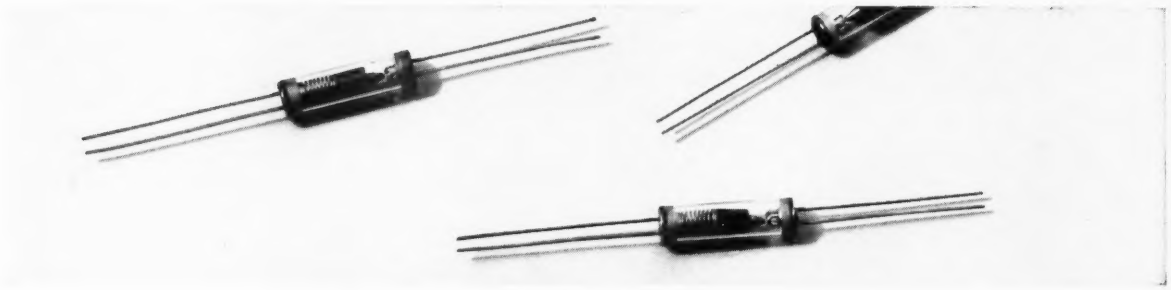
Put them to work today.
Write, wire or phone:
Arthur C. Cocagne, Director of Field Engineering, Whittaker Controls, a Division of Telecomputing Corporation, 915 North Citrus, Los Angeles, California.
Phone—HOllywood 4-0181.

Field offices—Indianapolis, Atlanta, Seattle, Wichita, Fort Worth, Hempstead (Long Island), N.Y.

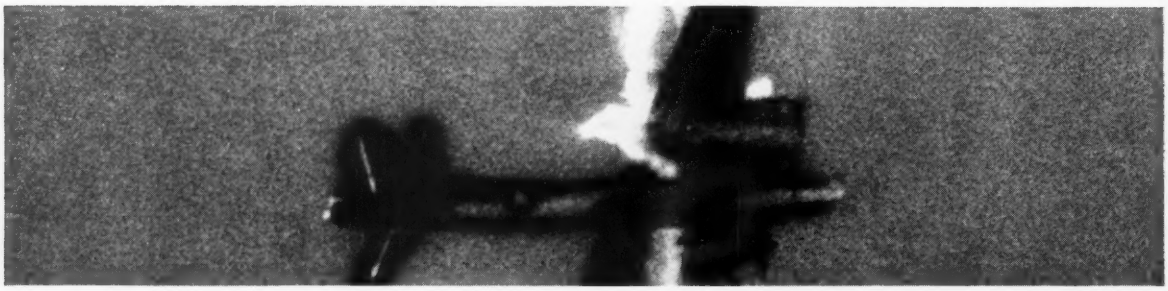
WC

WHITTAKER CONTROLS
A Division of Telecomputing Corporation
Brubaker Electronics • Whittaker Gyro
Data Instruments • Engineering Services
Whittaker Controls • Nuclear Instruments

HUGHES THERMAL RELAYS



FOR RELIABILITY



IN GUIDED MISSILES

Hughes now makes commercially available a completely reliable single action switch. Used in the Falcon, field proven as a reliable missile, this Hughes relay is engineered to meet the most exacting of requirements.

With unusual speed of action, firing signal triggers the release of constrained contact... contact closes upon fixed contact point... switch circuit becomes permanently closed.

In a typical application, 3.0 volts DC applied to a firing circuit of 1.2 ohms fire within 0.3 seconds.

For additional information please write: Hughes Products Marketing Department, International Airport Station, Los Angeles 45, California.

SPECIFICATIONS

MECHANICAL—Body Size: Maximum diameter 0.252″; length .920″. Total weight: Less than 0.1 oz.

ELECTRICAL—**Before Firing:** Insulation resistance is greater than 200 megohms. Minimum breakdown voltage 600 volts.

Firing: 2 volts minimum required. Actual voltage dependent upon closing time desired.

After Firing: Circuit resistance less than 0.3 ohm.

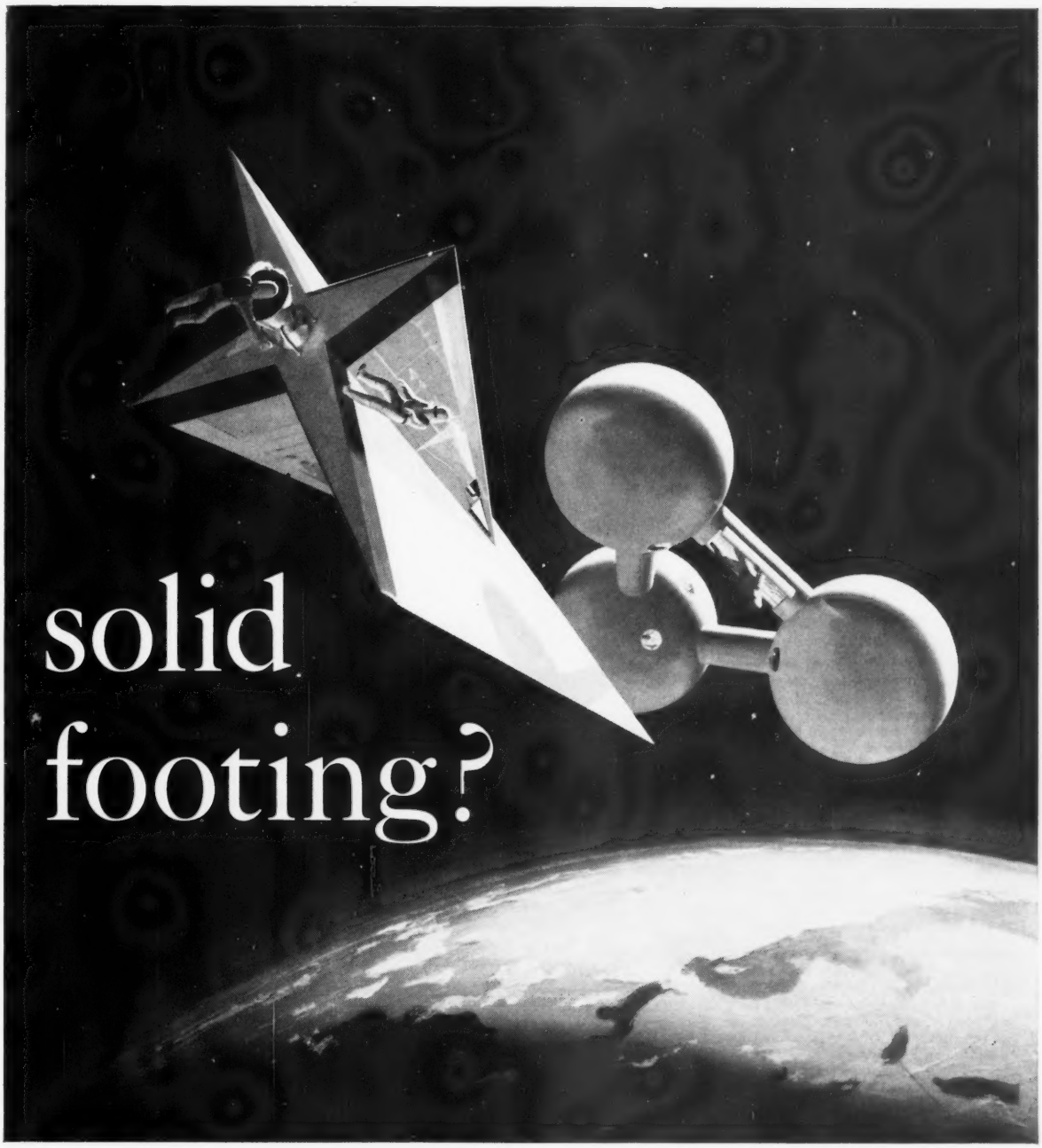
ALTITUDE—Any.

OPERATING TEMPERATURE: −55°C to +125°C.

Creating a new world with ELECTRONICS **HUGHES PRODUCTS**

SEMICONDUCTOR DEVICES • STORAGE AND MICROWAVE TUBES • CRYSTAL FILTERS
OSCILLOSCOPES • RELAYS • SWITCHES • INDUSTRIAL CONTROL SYSTEMS

© 1958, Hughes Aircraft Company



To a man floating weightless around Space Station C, these are perhaps meaningless words—but *solid footing* is highly important to most of us who live and work on the surface of the earth.

Autonetics has established a solid footing in inertial guidance through 12 years of successful development and production of airborne and ocean-going systems, as well as systems for space applications.

The healthy growth of the Autonetics Guidance Engineering department—based on a number of highly diversified contracts—has created new senior-level positions in the fields of electro-mechanical component development and system analysis.

Well qualified, experienced men will find solid footing in this permanent, progressive, and successful organization—plus the chance to create and to grow in one of today's most challenging fields.

But time's a-wasting. *Now* is the time to find out what the future holds for *you* at Autonetics.

Please send your resume to Mr. M. M. Benning, Manager, Employment Services, 9150 E. Imperial Highway, Downey, California.

NERVE CENTER OF THE NEW INDUSTRIAL ERA **Autonetics**
A DIVISION OF NORTH AMERICAN AVIATION, INC.

PROPULSION SPECIALISTS

Bell Aircraft Corporation offers you outstanding high level positions in the Propulsion Department of its *Space Flight and Missiles Division.*

Experienced specialists are needed to assume the responsibility for conducting analytical and/or experimental investigations in specified fields as related to advanced propulsion technology. These challenging and unique positions offer you opportunities for technical advancement as well as professional and financial growth.

AEROTHERMODYNAMIC SPECIALIST to work on supersonic aerodynamics, boundary layer flow, heat transfer and combustion problems. 5-7 years of experience related to supersonic inlet and exhaust nozzle design including dissociation effects required. Ph D desirable.

RAMJET SPECIALIST for preliminary design, evaluation and selection of ramjet engines and components for advanced missile programs. MS degree or equivalent plus 10 years progressive and intensive experience in all phases of ramjet engine research, design and development desired.

TURBOJET SPECIALIST to assume responsibility for preliminary design, evaluation and selection of turbojet engines and components for advanced missile programs. MS degree or equivalent plus 10 years progressive and intensive experience in all phases of turbojet engine research design and development desired.

THERMOCHEMICAL SPECIALIST to deal with transport properties of gases at high temperatures, dissociation and recombination phenomena and rates, high temperature gas and surface interaction and boundary layer flows involving sublimation or combustion. Ph D plus 5-7 years directly related experience desired.

SOLID PROPELLANT ROCKET ENGINE SPECIALIST to engage in preliminary design, evaluation and selection of solid propellant rocket engines for advanced missile programs. MS degree or equivalent plus 10 years progressive and intensive experience in solid propellants, grain configuration, combustion and hardware desired.

Salaries are commensurate with your background. Living and working conditions are excellent and employee benefits outstanding.

Write:

SUPERVISOR, ENGINEERING EMPLOYMENT, DEPT. Y-62

BELL AIRCRAFT CORPORATION
BUFFALO 5, NEW YORK

Experimental Missile Firings

(CONTINUED FROM PAGE 20)

Telemetry data and external motion picture coverage are the most reliable sources of data. The flight will usually be along a noncritical azimuth, and data of modest accuracy for velocity and position of the missile during its flight will usually suffice.

However, as the mission assignment reaches the phases of closed-loop guidance flight, where, among many other things, the ability of the missile to reach a target within the specifications prescribed by the user must be demonstrated, tracking systems of adequate ranging power must be ready and calibrated to yield exact position and velocity data. This in itself is a development task of major magnitude. Therefore, new principles are constantly under investigation and the development proceeds along several different lines of approach.

Optical systems are usually credited with the highest obtainable accuracy, and are used as primary laboratory standards. While their practical use is strongly limited due to their weather dependency, they serve well for calibration of electronic systems, using missiles as carriers for transponders and light flashes. In precision tracking with electronic equipment, we are probing around in the border areas of knowledge. Progress in this respect has failed to keep step with missile advances.

All this requires elaborate and extensive ground instrumentation devices, which, as has already been noted, are still in a vigorous multilane status of evolution. Unfortunately, it also calls for hundreds of pounds of equipment in the form of transmitters, receivers, transponders, beacons, pyrotechnic flares, timers, antennae with special patterns, power supplies, etc.

Not only is this equipment a source of permanent irritation to the designer from the viewpoint of "useless" dead weight, but it must also be systematically designed for integration into various batches of test missiles. Both the missile and the proving ground instrumentation form an integrated system. One is useless without the other, and both must advance hand in hand.

Problems concerning impact areas tax the ingenuity of our instrumentation designers for missiles of various ranges. One has to know with what precision a preselected target can be hit. This and other data acquisition problems require proximity to land masses, and another facet of the tracking problem emerges here—that of obtaining continuous and reliable knowledge of the whereabouts of the missile for the Flight Safety Officer.

Even a small turn to the wrong side made by a missile while its engines are functioning may put it into a flight path which will jeopardize inhabited areas. Several mutually independent systems for redundancy must be provided to give instantaneous information about missile position and velocity vector, for, if the Flight Safety Officer loses this information, he will be forced to terminate propulsion and give the "destruct" signal.

The preparation and successful execution of the experiment requires that all contributing systems and components operate simultaneously and harmoniously during the active lifetime of the missile in the complex laboratory prepared for it. It takes dedication and expert contributions from thousands of engineers, technicians and scientists in many fields of knowledge and experience to achieve success.

Substandard work on material or a human error can usually be detected and corrected without serious consequences as long as the test subject remains on the ground. When preparing a missile or ground system for flight, however, the consequences of neglect, poor judgment or error can easily become catastrophic. Once the missile is committed to flight, the intermittently malfunctioning component which has not been discovered, the cold solder spot that shakes loose, the undetected wiring error, the faulty ground data transmission line, may start an irrevocably chain of events that can bring about abortion of the missile flight or result in loss of mission data.

It is true that occasionally such a complete abort happens in our laboratory and a missile is expended without serving any useful purpose whatever. It is also true that the advance of our missile projects attests to the high standards employed in our experiments, and to the conscientious acceptance of responsibility by each individual worker who is a member of the firing and proving ground team. It is the concerted effort of the thousands of dedicated workers in these areas, as well as those in the areas of planning, designing, manufacturing and captive testing, which gave the Western world its first satellite.

It will be through these people, who carry their share of responsibility, who accept and resolve challenging problems, and who will continue to lose many hours of sleep over such problems, that space capabilities and defense mechanisms of the future will come.

Out of the multiplexed experiments conducted by the laboratory will evolve a rugged, simplified, reliable,

all-weather weapon system capable of mobile operation over all terrain. Within the weapon system will be the missile whose prototype was used as a test vehicle at the experimental lab.

When the missile reaches its berth in this tactical environment, its umbilical cord will have been served completely from the laboratory environment. The facilities will be simplified and truck-mounted; the instrumentation will no longer exist. And then the scientists and engineers will have been replaced by a small group of trained soldiers, one of whom will employ a pushbutton to fire the missile.

Astronautics at Statler

(CONTINUED FROM PAGE 45)

tural Considerations of Manned Space Vehicles" (ARS 732-58), Anthony P. Coppa of GE's Missile and Space Vehicle Dept. suggested that the structure of a manned space ship is likely to evolve through compromises aimed at providing optimum vehicle design through the compatible blending of many and varied technical disciplines.

Since design of a manned space vehicle demands consideration of such different problems as atmospheric entry, heat protection, meteoroid protection, and landing, integration of the various disciplines involved must be considerably more intimate than in ordinary aircraft practice, the paper noted.

Early Testing

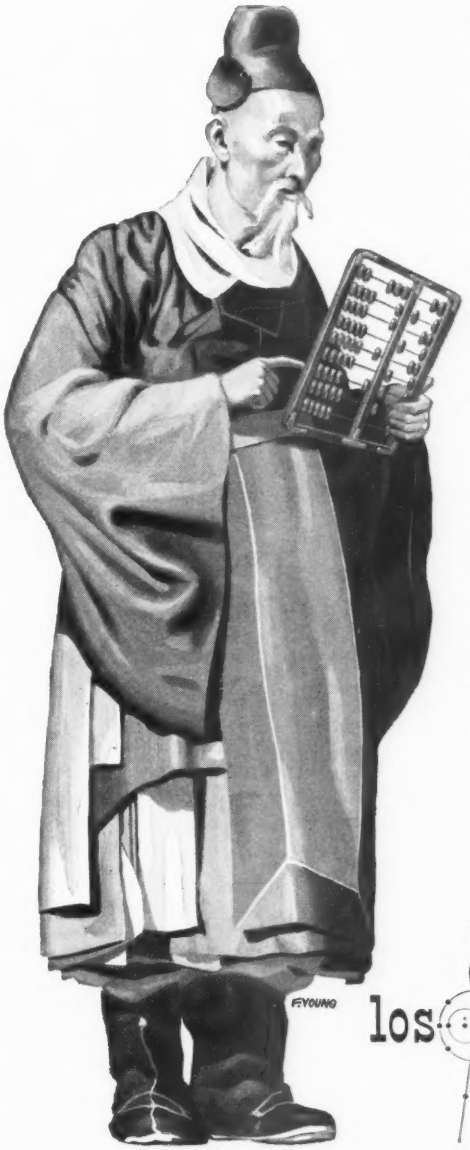
(CONTINUED FROM PAGE 37)

structure revealed no problem of yielding within the structure itself. An examination of the joints, however, showed that excessive elongation was occurring in the bolts joining the sections of the mast together. Redesign of mast joints resulted in satisfactory within-limits load-tests and, because the deficiency had been discovered early in the program, all existing masts were modified before delivery to the prime contractor.

Complete stress analysis of structures of the type utilized in Thor ground support equipment is very difficult. Despite the fact that stress analyses were made, static load-testing proved invaluable—particularly when the testing was done early.

With the correction of deficiencies at an early stage and the incorporation of improved designs, it is possible to get a more complete picture of the various items during the functional testing phase and thus insure that ground support equipment will operate properly in the field.

IT ALL ADDS UP!



A modern laboratory doing vital work in the field of nuclear energy.

A location in the spectacular setting of northern New Mexico's green pine-covered mountains.

A bright, clean community of 13,000 people, with up-to-date shops, uncrowded schools, cool summers and brilliantly sunny winters.

Whether you use an oriental abacus or the latest electronic computer, Los Alamos offers a remarkable total of attractive features. The Laboratory has a limited number of openings for highly qualified people in the physical sciences and engineering.

Write Personnel Director, Division 58-21

los alamos scientific laboratory
OF THE UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO

ARS news

Nuclear Propulsion Session Planned for San Diego Meeting

A Nuclear Propulsion session is scheduled for the ARS Semi-Annual Meeting in San Diego June 8–11, 1959, according to C. J. Wang of Space Technology Laboratories, vice-chairman of the ARS Nuclear Propulsion Technical Committee. Contributors are invited to submit papers for the session to Stanley Gunn, Rocketdyne, 6633 Canoga Park Ave., Canoga Park, Calif., by Feb. 1.

S. Ohio Section Offers Prizes for Student Papers

In an effort to broaden interest in the study of astronautics, the Southern Ohio Section will award prizes to the three best papers on topics associated with rockets, missiles, and space craft submitted by undergraduate students enrolled in degree-granting colleges within 50 miles of Cincinnati. First prize is a $25 U.S. Savings Bond; second prize, a year's membership in ARS and subscription to both JET PROPULSION and ASTRONAUTICS publications; and third prize, a certificate of merit. The deadline for submission of papers is April 30, 1959. Mail entries, or write or phone for further information, to George C. Szego, General Electric Co., Cincinnati 15, Ohio; Phone: POplar 1-4100 Ext. 3609.

Free Radical Symposium

"Trapped Radicals at Low Temperatures" will be the theme of the Fourth International Symposium on Free Radical Stabilization, sponsored by the Faraday Society, and to be held at the National Bureau of Standards in Washington, D.C., on Sept. 2–4, 1959. Emphasis will be given to the properties of solids containing trapped radicals, and the interactions —both chemical and physical—involving trapped radicals at low temperatures.

"Round Trip to Mars"

This was the title of a series of 10 lectures on principles of space flight sponsored by Lawson YMCA of Chicago and given by research scientists of the Illinois Institute of Technology. The lectures, which were held at Lawson, cost $15 per person and ran between Oct. 6 and Dec. 8.

SECTIONS

Antelope Valley: The unfortunate death of Capt. Ivan Kincheloe, section president, and the transfer of two other officers led to selection of the following members as officers who will serve until the next annual election: Walter A. Detjen, president; Robert E. Cundiff, vice-president; Palmer L. Long, secretary; and Theodore A. Sundahl, treasurer.

The first fall meeting was held Sept. 25 at the Experimental Test Pilots School Auditorium, and was followed by dinner and a social hour. Members heard a classified talk by **Charles H. Terhune Jr.,** Col., USAF, who is deputy commander for technical operations at BMD.

Central Colorado: The first meeting of the 1958–59 season was held Sept. 25 with 128 members and guests in attendance. After a few opening remarks by section president Elliot Ring, the program chairman, J. H. McKenna, introduced **Joseph Kittinger,** Capt., USAF, the principal speaker. The talk covered the psychological and physiological aspects of Capt. Kittinger's training for his 96,000-ft balloon ascent June 1957. Capt. Kittinger provided the commentary for motion pictures taken before and during the flight. A question and answer period was held after the showing of the film.

—**Martin M. Koshar**

Chicago: At the Oct. 25 meeting, **Kurt Stehling** addressed 36 members on "The Space Beyond the Satellites."

He made some very sobering comparisons between Soviet and American satellite efforts, mentioning that orbiting a 3000-lb satellite indicated a capability of striking parts of the U.S. with missiles. Stehling pointed out that the American tendency toward miniaturization required a superior guidance system while the larger Soviet vehicles did not require the same high degree of accuracy of parts. He cautioned, however, that the Soviets are probably very proficient in making an accurate guidance system.

With reference to propellants, Stehling advanced the opinion that liquid propellants will be with us for a long time—particularly with lox (liquid oxygen) as an ingredient. At the same

AMERICAN ROCKET SOCIETY

500 Fifth Ave., N. Y. 36, N. Y. Pennsylvania 6-6845

OFFICERS

George P. Sutton, President
James J. Harford, Executive Secretary
Robert M. Lawrence, Treasurer
John P. Stapp, Vice-President
A. C. Slade, Secretary
Andrew G. Haley, General Counsel

BOARD OF DIRECTORS

(Terms expire on dates indicated)

Krafft Ehricke, 1959
S. K. Hoffman, 1958
Simon Ramo, 1960
H. W. Ritchey, 1959
H. S. Seifert, 1958
K. R. Stehling, 1958
Martin Summerfield, 1959
Wernher von Braun, 1960
Maurice J. Zucrow, 1960

TECHNICAL DIVISION CHAIRMEN

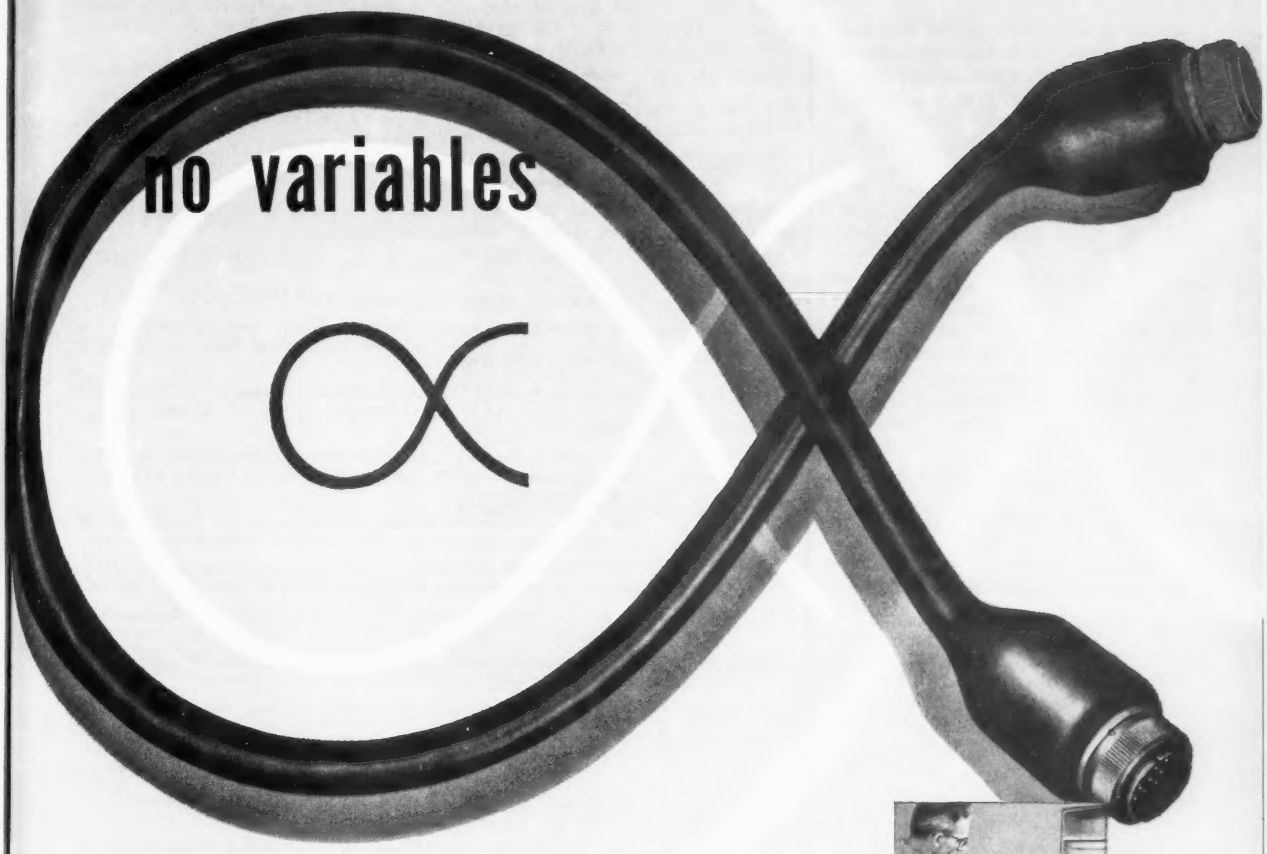
Lawrence S. Brown, Instrumentation and Guidance
Milton U. Clauser, Magnetohydrodynamics
Krafft A. Ehricke, Space Flight
Stanley V. Gunn, Nuclear Propulsion
Y. C. Lee, Liquid Rocket
Brooks T. Morris, Ramjet
David G. Simons, Human Factors
John Sloop, Propellants and Combustion
Ivan E. Tuhy, Solid Rocket

COMMITTEE CHAIRMEN

S. K. Hoffman, Finance
Simon Ramo, Publications
H. W. Ritchey, Membership
H. S. Seifert, Program
Kurt Stehling, Awards
Martin Summerfield, Policy

eliability that knows

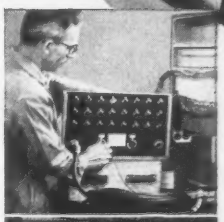
no variables



eliability in an electronic cable is the result of applying the most advanced
ble technologies, thus providing the right answer for every variable that contributes
the performance of the end product.
ables by Pacific Automation Products are reliable for these specific reasons:

- Every conductor and jacket which enters the PAP plant is carefully inspected.
- Every cable is custom designed to the customer's specifications or requirements.
- Every cable is fabricated to give optimum structural conformity, maximum flexibility, and greatest strength.
- Each cable is inspected and tested at every stage of the fabrication process.
- Assembly is completed at the plant, under rigid Quality Control surveillance, by highly skilled people. Each cable leaves the plant ready for installation. The variables of field fabrication or assembly are eliminated.
- Every cable is tested for electrical integrity. Environmental tests are performed to simulate conditions of heat or cold to prove flexure characteristics and abrasion resistance.
- Every PAP cable is mechanically, electrically, and environmentally suited to the most exacting service that may ever be required of it.

ut PAP's cable specialists to work for you today. Phone, write or wire:



Pacific Automation Products, Inc.

0 AIRWAY, GLENDALE 1, CALIFORNIA *Phone: CHapman 5-8661 CItrus 6-2411*

137 Walnut Hill Village, Dallas 20, Texas • FLeetwood 7-5751
626 Jefferson Street, Redwood City, California • EMerson 9-2991
420 Lexington Avenue, New York, N. Y. • LExington 2-5193
4355 North Atlantic, Cocoa Beach, Florida • Cocoa Beach 2059

NGINEERS: THIS COMPANY HAS IMAGINATION, YOUTH, SPIRIT, AND GREAT GROWTH POTENTIAL. WHY NOT SEND YOUR RESUME TODAY?

time, he feels the importance of solid fuels will continue to grow. He believes that Mars represents the range limit of space craft powered by current chemical propellants. In response to questions from the audience, he indicated that he does not know of a plan to reach that planet.

In describing basic problems in launching and obtaining information from "Big Brother" scanning satellites (equipped with TV cameras to scan the earth's surface), Stehling pointed out the difficulty of obtaining accurate visual recordings by means of present-day cathode ray tubes. The speed of the satellite itself would require the camera to be moved through a wide reference angle to "catch" an area of interest. The tendency of the satellite not to pass over the same identical area on two successive passes would be maddening to an observer. His answer to the question, "Could these satellites be shot down?" was "No, it would be unlikely because they would be exceedingly hard to hit." Stehling said he hoped these astronautical efforts would be put to peaceful purposes.

He then outlined the inherent advantages of an observatory on the moon, noting that much more could be learned about space above the clutter of our own atmosphere. With further reference to his opinion that Mars represented the present limit of chemical propulsion systems, Stehling concluded his remarks with the statement that an electrical propulsion technique would greatly increase our range of exploration in space.

—**Jim Summers**

Space Talk

Tuning up for space talk, Kurt Stehling passes a word with Chicago section president J. S. Fraenkel during October meeting. Standing, left to right, are other officers of the Chicago section: George Herman, treasurer; Joseph Elward, vice-president; and Ben Harrison, secretary.

On the calendar

1958	
Dec. 2–4	3rd Electronic Industries Assn. Conference on Reliable Electrical Connections, Statler-Hilton Hotel, Dallas, Tex.
Dec. 3 4	2nd National Symposium on Global Communications, jointly sponsored by IRE and AIEE, Colonial Inn, Desert Ranch, St. Petersburg Beach, Fla.
Dec. 6–10	Annual Meeting of American Institute of Chemical Engineers, Netherland Hilton Hotel, Cincinnati, Ohio.
Dec. 17	Wright Brothers Lecture, sponsored by IAS, Natural History Bldg., Smithsonian Institution, Washington, D.C.
Dec. 26–31	125th Annual Meeting of the American Assn. for the Advancement of Science, Washington, D.C.
Dec. 29–31	1958 American Physical Society Western Winter Meeting in the West, Univ. of California, Los Angeles.
1959	
Jan. 26–29	27th Annual IAS Meeting, Sheraton-Astor Hotel, N.Y.C.
Jan. 28–29	1st International Symposium on Nuclear Fuel Elements, sponsored by Columbia Univ. and Sylvania-Corning Nuclear Corp., at Columbia Univ., New York, N.Y.
Jan. 28–29	5th Annual Midwest Welding Conference, sponsored by Illinois Inst. of Technology and American Welding Society, IIT Chemistry Bldg., Chicago.
Feb. 3–5	14th Annual Technical and Management Conference of the Reinforced Plastics Div. of The Society of the Plastics Industry, Edgewater Beach Hotel, Chicago.
Feb. 5–6	Industrial Management Engineering Conference at Illinois Inst. of Technology, Metallurgical and Chemical Engineering Bldg., Chicago.
March 3–5	1959 Western Joint Computer Conference, sponsored by IRE, AIEE, and Assn. for Computing Machinery, Fairmont Hotel, San Francisco.
March 8–11	Turbine in Action Symposium, sponsored by ASME Gas Turbine Div., Cincinnati, Ohio.
March 19–20	Flight Propulsion Meeting, sponsored by IAS, Hotel Carter, Cleveland, Ohio.
March 23–25	**ARS Spring Meeting, Daytona Beach, Fla.**
March 31 and April 1–2	Millimeter Waves will be the theme of 9th International Symposium of Polytechnic Institute of Brooklyn (N.Y.) Microwave Research Inst., co-sponsored by AFOSR, Army Signal R&D Lab, ONR, and IRE.
April 5–10	5th Nuclear Congress of Engineers Joint Council, Cleveland Auditorium, Ohio.
April 6–10	40th Annual Convention of the American Welding Society, Chicago.
April 22–24	3rd Annual Technical Meeting of the Inst. of Environmental Engineers, LaSalle Hotel, Chicago.
May 25–27	**National Telemetering Conference, co-sponsored by ARS, AIEE, IAS, and ISA, Denver, Colo.**
June 8–11	**ARS Semi-Annual Meeting, San Diego, Calif.**
June 11–13	1959 Heat Transfer and Fluid Mechanics Institute, Univ. of Calif., Los Angeles.
Aug. 24–26	**ARS Gas Dynamics Symposium, Northwestern Univ., Evanston, Ill.**
Sept. 13–20	**10th Annual International Astronautical Federation Congress, London, England.**
Nov. 16–20	**ARS 14th Annual Meeting, Washington, D.C.**

Cleveland-Akron: The section held a dinner meeting jointly with the Twin Cities section of IAS on Nov. 3 at the Curtis Hotel in Minneapolis. Guest speaker was **John L. Sloop**, chief of the Rocket Engines Branch of NASA's Lewis Research Center. Mr. Sloop was instrumental in organizing the Cleveland-Akron section and has been its president. He discussed a subject very familiar to him, "High-Energy Propellants—Their Use and Future," describing both propellants proper and the great amount of engineering that must be done to develop space vehicle engines able to use them. This talk was well received, and was timely in view of the prospects for high-energy chemical rockets for space flight.

Columbus: The section opened the 1958–59 season with a meeting held jointly with the local section of IAS at Battelle Memorial Institute Sept. 16. Some 70 in attendance heard **Robert**

AERO-THERMODYNAMICISTS EXPLORE HIGH-SPEED RE-ENTRY

A report to Engineers and Scientists from Lockheed Missile Systems — where expanding missile programs insure more promising careers

Advanced weapon system technology has brought to the forefront problem areas requiring attention to interaction between aerodynamic and thermodynamic phenomena. Typical of these is the problem of high-speed atmospheric re-entry.

Expanding research and development activities have coincided with acceleration on top priority programs like our Polaris IRBM. At the same time, positions for qualified engineers and scientists have opened up that are unequalled in responsibility or in opportunities for moving ahead.

Positions in **aero-thermodynamics** include such areas as: aerodynamic characteristics of missiles at high Mach numbers; missile and weapon system design analysis; boundary layer and heat transfer analyses in hypersonic flow fields; and calculation of transient structural and equipment temperatures resulting from aerodynamic heating and radiation.

In addition, openings exist at all levels in **Gas Dynamics, Structures, Propulsion, Test Planning and Analysis, Test Operations, Information Processing, Electronics,** and **Systems Integration.** For these and other positions, qualified engineers and scientists are invited to write Research and Development Staff, Dept. 1412, 962 W. El Camino Real, Sunnyvale, California.

Lockheed MISSILE SYSTEMS DIVISION

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO

Maurice Tucker, Aero-Thermodynamics Department Manager, right, discusses combined aero-thermodynamic re-entry body tests being conducted in Division's new "hot-shot" wind tunnel. Others are Dr. Jerome L. Fox, Assistant Department Manager, Thermodynamics, left, and Robert L. Nelson, Assistant Department Manager, Aerodynamics.

Lusser discuss "The Notorious Unreliability of Complex Missile and Aircraft Equipment."

The first meeting of the Women's Auxiliary was held on Sept. 23, the ladies choosing officers and discussing their first project—a plaque for the outstanding girl student in science from Columbus high schools. Elected were Mrs. M. W. Jack Bell, president; Mrs. Abbott Putnam, vice-president; Mrs. James L. Harp, secretary; and Mrs. Thomas Kirk, treasurer.

—Dean L. Pendleton

Dayton: The section met Oct. 22 at the Sky Terrace Room of the Miami Hotel, with Avco Mfg. Corp. as cordial host. This was the first of a series of meetings that will be sponsored by corporations having membership in the AMERICAN ROCKET SOCIETY.

Some 100 members and guests heard **Ralph W. Detra** of Avco Research Labs speak on "Design Considerations of a Manned Satellite." Dr. Detra discussed some of the outstanding considerations of a manned satellite, particularly the aspects of launching, vehicle reliability, guidance accuracy, satellite capsule design, and environmental requirements for man. He also discussed re-entry and recovery techniques.

Other guests of the Section were Herman Epstein and Edwin Hartley of Tele-Dynamics.

—Wm. J. Cushing

Florida: The regular monthly meeting was held Sept. 26 in Patrick's Technology Lab. Opening the meeting, section president R. F. Sellars, Capt., USN, reviewed progress in the program of section-sponsored courses in astronautics for Brevard high school teachers. Classes have been held on rocket fundamentals (George Woodruff) and celestial mechanics (Robert Ronay). If this program proves successful, it will be continued into 1959. Capt. Sellars announced that the West Palm Beach section of ARS was being organized. Several members of this section were present to arrange for an exchange of information and speakers. Capt. Sellars at this meeting also encouraged the membership to submit technical papers to ARS publications and conventions.

The members then heard guest **William F. Main,** manager of the electronics research div. of Lockheed Missile Systems Div., discuss space communications. In Main's opinion, it would take little extension of present techniques to be able to communicate with a space vehicle in the neighborhood of Mars, which is some 35 million miles away at its closet approach. Significant extensions of range could be achieved without a proportional increase in power by utilization of a narrower bandwidth for the communication link. Main also suggested that it might be possible to overcome the formidable obstacle presented by earth's heavy atmospheric and ionospheric curtain by positioning a satellite in a 300-mile orbit to relay messages between the earth and interplanetary space craft. Main discussed how range could be extended by coded signals.

Other areas of potential advances in the state of the communications art, he said, include improved amplifiers, antennas, and transmission lines, as well as higher efficiency power supplies, such as solar batteries and the so-called fuel cell, which produces electric power directly from the chemical reaction of a fuel and oxidizer.

At the Oct. 24 meeting, held in the Missile Room of Patrick's officers club, James J. Harford, ARS executive secretary, discussed plans for the spring meeting at Daytona Beach. Also, candidates were nominated for 1959 section posts.

—Ballard B. Small

Holloman: Knox Millsaps, chief scientist at the AF Missile Development Center, was unanimously renominated for an unprecedented second term as president of the section.

National Capital: The section recently held the first of 10 Saturday programs to train a teacher and an outstanding science student from each of a number of local schools in safe methods for high school rocket education. These programs are being conducted with the help of the Army Corps of Engineers, the Association of Missile and Rocket Industries, and such prominent companies as Aerojet-General, Atlantic Research, Diversey Engineering, Melpar, Rocketdyne, and Thiokol Chemical.

The first in the series, on Nov. 8, featured a "Trip to Mars" in the Army Engineer's planetarium. The following week the group visited a Nike-Hercules site. Other programs will cover careers in missile ground support, history of rocketry, rocket chemistry, design and flight principles of a simple rocket, guidance systems, and the physics of a flight path.

New New England Officers

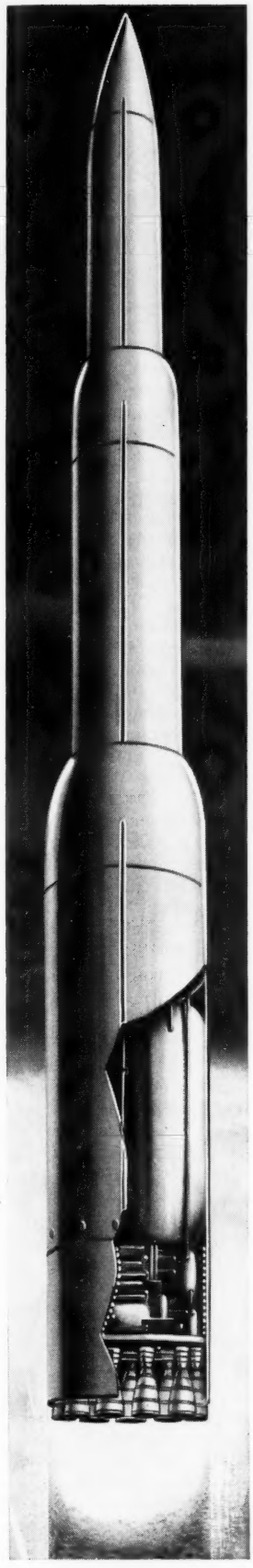
New officers were elected at the first fall meeting of the New England section, held at the MIT Faculty Club. Left to right: Joseph E. Lavelle of GE, secretary; Fred P. Durant III of Avco, former national president of ARS; George P. Sutton, national president of ARS and visiting professor of aeronautical engineering at MIT; John Harvell of Arthur B. Little, Inc., president; Peter Rose of Avco Research Laboratory, a director; and John C. Herther of ITEK, vice-president.

New England: The section opened its 1958–59 season in a meeting Oct. 16 at the MIT Faculty Club in Cambridge.

Presented to members and guests were new section officers: John T. Harvell, president; John C. Herther, vice-president; Joseph E. Lavelle, secretary; and A. John Gale, treasurer.

The section also had the pleasure of two guest speakers. **Bernard Vonnegut,** of Arthur D. Little, Inc., showed a film about current research on weather phenomena, and answered questions covering the research he has been conducting in Cambridge and New Mexico on the role of atmospheric electricity in thunder storms.

George P. Sutton, visiting professor of aeronautical engineering at MIT, on leave of absence from his position as Manager of Advanced Design at Rocketdyne, spoke to the members about the purpose of the Society and its place in the American scene. After showing "Road to the Stars," a Rocketdyne film on the history and growth of rocket power and astronautics, he answered questions concerning present and projected liquid propulsion systems.



COUNT DOWN

for the conquest of space

IS THE ROCKET ENGINE MAN'S ONLY WAY TO OUTER SPACE?

Strapped and cushioned against the relentless grip of acceleration, a man lies supine and helpless as his crew of robot devices controls the upward drive of his ship. He watches the firing seconds tick away—300 ... 450 ... 600—until suddenly, both sound and acceleration stop simultaneously. In that second all weight ceases.

He is in Outer Space.

The only power that can put him there today is the large rocket engine. No matter how far and how fast space travel develops, these high-thrust engines provide one basic essential—the sheer brute force that can lift a payload from the surface of the planet to the airless void outside.

Endurance for vast distances

Once space is reached, a wealth of intriguing possibilities beckons. Entirely new aspects of propulsion are being developed to maneuver ships between the moving gravitational fields of Earth's neighbours in the solar system.

PACKHORSE OF SPACE. *Only means to put stores or people out beyond atmosphere is the big, high-thrust rocket.*

One advanced propulsion system that may be built soon is an ion rocket. This ultra-high-specific-impulse power plant provides low thrust for extended periods.

OUTWARD BOUND, *man's robot reporter heads off to a rendezvous with planet Mars.*

An endurance of months, or even years, is possible. Mounted in a suitable unmanned vehicle, such an interplanetary "private eye" would make the cislunar region seem like our own front yard. It could be sent off to reconnoiter the mysteries of Mars, Venus, or the Asteroid Belt.

Rockets ready today

To date, the vast bulk of successful missile and space projects in America have used Rocketdyne engines—Atlas and Thor for the Air Force, Jupiter and Redstone for the Army, the historic Explorer satellites, and the all-important first stage of the lunar probes. And Rocketdyne continues to improve the techniques of rocket engineering. High-energy fuels—storability—a full range of proven engine designs: these are some of the contributions Rocketdyne has made to weapon system operation for our nation's defense.

Million pounds of thrust

Rocketdyne is now at work on two approaches to propulsion systems that will deliver thrusts up to 1,500,000 pounds. One is a single-chambered engine, the other a grouping of engines adapted from the Thor-Jupiter engine family. From these will stem the multi-million-pound-thrust systems that are essential to launch the manned exploration of interplanetary Space.

FIRST WITH POWER FOR OUTER SPACE

ROCKETDYNE

A Division of North American Aviation, Inc.—Canoga Park, California; Neosho, Missouri

New York: The section resumed its series of monthly technical meetings Sept. 26 with an address by **Sidney Darlington,** who is on the technical staff of Bell Labs, doing research in applied mathematics. Much of Dr. Darlington's work has related to anti-aircraft fire control, electronic bombsights, and missile guidance. He described some of the complexities of guidance for lunar probes and how these vehicles differ from the sort popularly understood from science-fiction writers. A large audience appreciated Dr. Darlington's timely and informative comments on our most ambitious attempts at space flight to date.

More than 300 members of the New York Sections of ARS and IAS attended the annual joint meeting of the two sections on Oct. 17. Featured speaker at the meeting was **Capt. Willoughby Mercer** (USN), director of the Navy BuAer Powerplant Div.

In his address on the evolution of propulsion systems for naval aircraft and missiles, Capt. Mercer reviewed the wide selection of powerplants available and pointed up some of the problems involved in present-day development work. He also discussed aspects of fleet use which affect or govern choices of propulsion systems, as well as powerplant economics with respect to aircraft or missile applications which play a major role in development, application, and certification philosophies.

Prior to the meeting, Fairchild Engine Div. sponsored a reception for members and guests.

St. Joseph Valley: The September meeting, held in the Engineering Auditorium of the Univ. of Notre Dame, had as guest speaker **Martin Steinberg,** a senior scientist of Armour Research Foundation's propulsion and Fluid Mechanics Research Dept., who is responsible for physical and chemical investigations with shock tubes and other equipment. Dr. Steinberg spoke on the fundamentals and limitations of the shock tube, the nature of data obtained with it, and some current results of shock tube studies.

Some 50 members and guests at the Oct. 8 meeting, held in the Nieuwland Science Hall of the Univ. of Notre Dame, heard **G. V. Bull,** superintendent of the Aerophysics Wing of the Canadian Armament R&D Establishment, Volcartier, Quebec, discuss the application of gun launching techniques to aerodynamic studies. Dr. Bull covered both aerodynamic stability, performance, and control studies in normal atmospheric ranges for conventional aircraft and rocket shapes up to Mach 6.5, and the development and application of light gas techniques to pressurized range facilities for study of problems arising in reentry.

At CARDE, Dr. Bull has been responsible for the development of hypersonic ranges for aerophysics research. Equipment there has at present the ability to fire models weighing over a pound to velocities up to 10,000 fps.

—B. A. Bishop

For Contributions to Rocketry

Peter Castruccio of Westinghouse receives Maryland Section's 1958 award for contributions to rocketry from Ivan Tuhy of The Martin Co. Active in both radar and propulsion research, Dr. Castruccio heads the recently formed Westinghouse Astronautics Institute.

St. Louis: Thomas N. Scortia, assistant manager for chemical research at Propellex Chemical Co. and well-known science-fiction writer, addressed the October meeting on "Nonchemical Propulsion Systems." His talk included a comprehensive review of propulsion systems suggested for space craft, with emphasis on systems most likely to be made practical in the near future. The meeting was held in the auditorium of the McDonnell Aircraft Corp., and was preceded by an informal dinner at Holiday Inn.

—Jim Holsen

Valley Forge: Members and guests at the Sept. 25 meeting, held in the auditorium of the Conestoga High School, heard I. M. Levitt, director of Fels Panetarium, speak on "What To Expect on the Moon." It was a pleasure to hear an informed astronomer speak on this subject. In addition, a short film on the Atlas missile was shown.

Wichita: The Sept. 26 meeting, held at Beech Aircraft, was attended by some 75 members and guests, who saw a movie of the launching of Explorer I. Special guests of the section were the young members of the Sedgwick County Rocket Club.

The Wichita section is endeavoring to assist students and youngsters ininterested in rocketry in this area. We are in particular assisting the Sedgwick County Rocket Club by arranging programs for them. In addition, we are attempting to secure them publicity and to work with the Wichita Board of Education, which has promised, as a part of their recreation assistance program, to provide a permanent meeting place, a library area, etc., for this rocket club. Larry McMurtrey, former section president, is senior adviser to this club, and has devoted a great deal of time to its activities.

We received a report from a high school instructor that the Wichita section sponsored at the Symposium at the Univ. of Oklahoma for high school instructors in rocketry. He received a great deal of information which will be of assistance to him in the present school term, and expressed his thanks to the Wichita section for their sponsorship.

The section is again participating in the Kid's Day program being sponsored by the USAF at McConnell AFB in Wichita. The Wichita section will have a static display and will sponsor a CO_2 wire-controlled rocket competition, as we did last year. Prizes of $5, $3, and $1 will be awarded to the winners.

To further promote ARS, various members of the Wichita section during the past few months have given lectures to various organizations on subjects pertaining to rocketry and space travel.

—R. Harvey Anselm

CORPORATE NEWS

Aerojet-General and Bristol Aeroplane Co., Ltd., have agreed to form a new joint company to be known as Bristol-Aerojet, Ltd., located in England, and devoted to development, manufacture, casting and testing of solid rocket motors, including propellant formulation. Exclusive rights to exploit Aerojet solid-propellant rocket products in the UK and British Commonwealth have been assigned to the new firm.

To meet the need for more skilled missile technicians, Aerojet, in cooperation with the International Assn. of Machinists, has embarked on a comprehensive apprentice training program at its Sacramento and Azusa plants.

Aeroquip Corp.'s General Logistics Div. has moved to a new office and factory building at 2929 Floyd St., Burbank, Calif., from its former Pasadena location. Aeroquip held an open house Nov. 18 at its new 10,000 sq ft plant in Dallas, Tex.

Avco Mfg. Corp. has acquired Pre-Flite Industries Corp., Paramount, Calif., producer of Air Torq, a pneumatic ground starting unit for turbojet and turboprop engines, and hydraulic tests stands. The acquisition complements Avco's weapon systems programs.

CBS Labs new research center in Stamford, Conn., which will serve as administrative and scientific headquarters, was formally opened Oct. 7. The research center will be used for R&D work in solid-state physics, physical chemistry, data processing systems, electronics for communications and other applications.

Callery Chemical dedicated its $38 million Navy HiCal plant in Muskogee, Okla., Nov. 1. The plant is the first known large-scale high-energy fuel facility.

Douglas has established a new Weapon Systems Div. to strengthen management and direction of the company's military programs.

IBM recently dedicated its new 570,000 sq ft manufacturing plant near Rochester, Minn.

Leach Corp. is in the final stages of completion of its new Production Reliability Center, where missile components and systems can be exposed to 500-g tests. The destruction lab will be available to all manufacturers, including component and airframe companies.

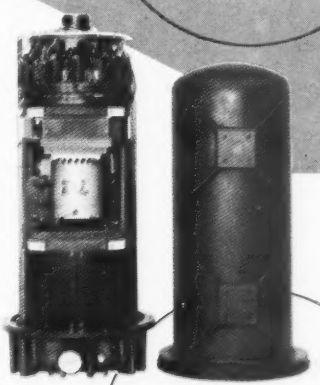
Lockheed Missile Systems Div. has let a construction contract for an $8 million addition to its Sunnyvale plant, where development work on an AF satellite will be centered.

Marquardt has acquired in a cash transaction the assets of Associated Missile Products Co., A Division of American Machine and Foundry, maker of electronic data processing and display systems and test modules for weapons system checkout. Marquardt dedicated its modernized Jet Lab on Oct. 19, and celebrated the occasion with an open house.

A recently completed 135,000 sq ft plant in Burlington, Mass., will house the newly established Missile Electronics and Controls Dept. of **RCA Defense Electronic Products.** The former Boston Airborne Systems Lab becomes part of the new department.

multiple commutation rates with CEC's versatile **PLEXICODER**

Commutation and PDM conversion of signals from up to 90 transducers now can be accomplished by the revolutionary Type 40-101 PLEXICODER at rates of 900, 225, or 112.5 samples per second. A simple field change of motor mounting and gear plates provides three or more instruments in one. The PLEXICODER converts single or double-ended, positive or negative, low-level inputs from strain gages and thermocouples for telemetering or magnetic-tape recording. Galvanometers (with their inherent filtering characteristics) and an optical system replace rotating wiper-arm assemblies and complex electronic circuitry. Over-all system accuracy is 1%. Maintenance in the field is accomplished without return to the factory . . . service-free life is a nominal 1000 hours. The PLEXICODER measures 25″ high by 8¼″ in diameter, is designed for missile, rocket, or manned aircraft applications . . . ideal for engine test stands, telemetering systems, and ground-based data-handling systems. Call your nearest CEC sales and service office, or write for Bulletin CEC 1599-X9.



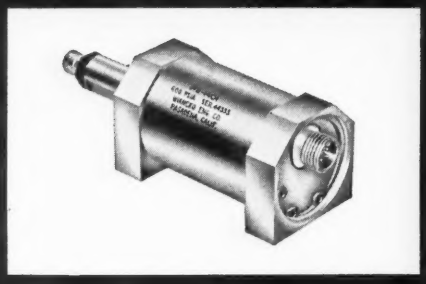
Transducer Division

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

RECOGNIZED LEADER IN GALVANOMETERS—TELEMETRY, PRESSURE AND VIBRATION INSTRUMENTATION

a variable-reluctance pressure transducer for dc applications



Wiancko's new dc-dc pressure transducer is a notable advance in transducer design that will find ready acceptance and wide appreciation because here, combined in a small 10-ounce package, are all the advantages of the variable-reluctance pick-off with the desirable features of dc excitation and output. High output (0-5 volts dc), great accuracy and repeatability, exceptional acceleration and vibration resistance, constant output impedance, and high frequency response, all make this transducer eminently suitable for telemetering and data system applications.

Available in gage, absolute, and differential models, this new Wiancko achievement will soon be incorporated in accelerometers and force rings. For more detailed information, write for Product Bulletin 108.

wiancko

Wiancko Engineering Company
255 No. Halstead Avenue • Pasadena, California

Field Offices

• **Eastern**
No. 2 South Maple Ave.
Ridgewood, New Jersey
Phone: GIlbert 4-2444

• **Northern California**
Cowper-Hamilton Bldg.
Palo Alto, California
Phone: DAvenport 6-7053

• **Southern California**
3410 E. Foothill Blvd.
Pasadena, California
Phone: ELgin 5-7186

Support Systems

(CONTINUED FROM PAGE 30)

Definite trends toward increased mobility and air transportability of engines and engine support items are being established. Conventional engine shipping containers are being replaced by mobile, lightweight engine transportation trailers. Trailers provide limited environmental protection for the engine and, with the cover removed, can support the engine during maintenance and repair operations.

Engines are normally handled in fixed shop facilities by overhead hoist. The freely suspended engine is easily positioned and aligned as required for installation in missile structure. When particular versatility is desired, or when an overhead hoist is not available, an engine can be moved by a mobile hydraulically operated crane. Rail transfer systems, such as those for handling conventional aircraft engines, are also utilized for some programs.

The majority of the large liquid propellant rocket engines in operation today incorporate speed reducing turbopump gear systems. These gears, and associated high-speed bearings, must be cooled and lubricated during operation, and preserved from corrosion during storage. Equipment required for these servicing operations is normally installed in mobile service units, such as that shown on page 29. Flushing and purging systems in these units can be also utilized for decontamination of fuel and oxidizer systems after static test or training operations. Units of this type may be utilized at launchers, maintenance shops and missile assembly plants.

Several engine support activities are evident at the launch site, as shown on page 28. Ground supplies of fuel and oxidizer, frequently utilized for engine starting, are installed in the vicinity of the launcher. A major portion of the engine control system is also associated with engine starting, and this equipment is normally ground-mounted to reduce the flight weight of the missile. Engines are serviced at the launcher, and provisions are sometimes made for removal and replacement of engines there.

Engine operations during the launch countdown are sequenced automatically from a control console in the blockhouse. Detailed engine sequence or status information may be displayed or summarized as desired. This equipment may also be utilized for checkout, or for isolation of malfunctions during routine maintenance operations.

Some Repairing at Launching Site

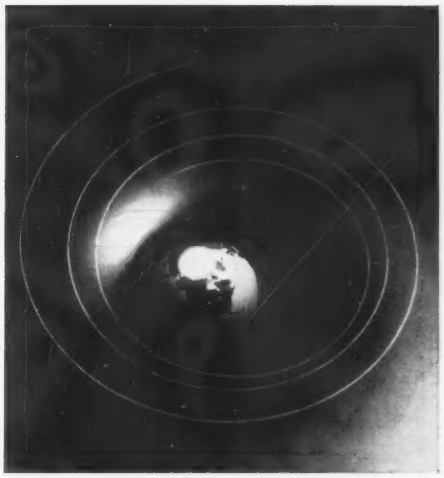
Engines are normally repaired by removal and replacement of malfunctioning components. Some work of this type can be done at launch sites, but it is often more appropriate to remove the missile from the launcher and to perform the work in an enclosed missile maintenance shop. If extensive engine repairs are required, the engine is removed from missile structure and transferred to an engine maintenance shop. The illustrations on page 30 show representative layouts of these shops.

Manual methods have been utilized for engine checkout in the past. Mobile units like the one pictured on page 29 are utilized for this purpose. Electrical, pneumatic and hydraulic power is controlled and supplied to the engine for actuation of control components. The engine components can be actuated individually or automatically in sequence. Test results are indicated by pilot lights and timers, and recorded if desired.

Automatic systems for engine checkout, programmed by perforated cards or magnetic tape, have been under development for some time, and some systems of this type are in use. Principal advantages are reduction in time required for checkout and lower skill levels for operating personnel.

Full performance checkout of rocket engines after installation or normal

For Peaceful Purposes and the Benefit of All Mankind The National Aeronautics and Space Administration Announces its Authorization by the Congress of the United States



To Direct and Implement U.S. Research Efforts In Aeronautics and the Exploration of Space

"The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives:

(1) The expansion of human knowledge of phenomena in the atmosphere and space;

(2) The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles;

(3) The development and operation of vehicles capable of carrying instruments, equipment, supplies and living organisms through space;

(4) The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes;

(5) The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere;

(6) The making available to agencies directly concerned with national defense of discoveries that have military value or significance, and the furnishing by such agencies, to the civilian agency established to direct and control nonmilitary aeronautical and space activities, of information as to discoveries which have value or significance to that agency;

(7) Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof; and

(8) The most effective utilization of the scientific and engineering resources of the United States, with close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities, and equipment..."*

The excitement, the importance, and the scope of the National Aeronautics and Space Administration are apparent, we believe, from our enabling act. Career opportunities at NASA are as unlimited as the scope of the organization itself.

Please address your inquiry to the Personnel Director of any of the following NASA research centers. Your inquiry will be answered immediately, and will be treated in the strictest confidence.

Langley Research Center, Hampton, Virginia
Ames Research Center, Mountain View, California
Lewis Research Center, Cleveland, Ohio
High-Speed Flight Station, Edwards, California

*Quoted from the National Aeronautics and Space Act of 1958.

(Positions are filled in accordance with Aeronautical Research Scientist Announcement 61B)

NASA National Aeronautics and Space Administration

THE ATLAS LAUNCH
CONTROL AND CHECKOUT
SYSTEM IS REPRESENTATIVE
OF THE DEFENSE
PROJECTS CURRENTLY UNDER
DEVELOPMENT AT RCA
MOORESTOWN.
ENGINEERS AND SCIENTISTS
WHO ARE INTERESTED AND
QUALIFIED IN THE FIELDS OF
MISSILE GUIDANCE
MISSILE GROUND SUPPORT
AND HIGH POWER,
PRECISION RADAR ARE
INVITED TO CONSIDER
AVAILABLE CAREER
OPPORTUNITIES.
SALARIES TO $17,000
PLEASE DIRECT YOUR INQUIRY
TO MR. W. J. HENRY, BOX V-22M
ADDRESS BELOW

EQUAL JOB OPPORTUNITY For All Qualified Applicants

RCA®

RADIO CORPORATION of AMERICA
Missile and Surface Radar Department
Moorestown, N. J.

maintenance is not normally required. Heavy maintenance work is performed at engine depots, which are equipped with complete engine static-test and calibration facilities.

Components, when removed from engines or support equipment, are repaired by replacement of faulty or suspect parts. Repaired components are then subjected to functional test on stands like the one shown on page 29. This equipment may also be utilized for verifying the quality of replacement components removed from stock.

Methods and procedures for automatic testing of components are also being studied. Such methods appear particularly appropriate for electrical components, but may prove more difficult to apply to pneumatic and hydraulic items.

Von Kármán Honored

Theodore von Kármán has received the ASME Timoshenko Medal for his "outstanding contribution to the mechanics of fluids and solids, particularly those leading to major advancements in aeronautics."

Polaris Corrosion Prevention

(CONTINUED FROM PAGE 39)

parts and components used in fabricating Polaris.

3. Use of temporary protective strippable coatings precludes damage and deterioration during shop handling, fabrication and assembly of some of the more vulnerable materials and parts. Stripping methods are scrutinized to prevent adherence of particles or use of removal materials which can cause corrosion.

4. In view of the lack of an adequate finishing specification adaptable to the needs of the Polaris flight article, a new specification embodying the latest inorganic and organic protective treatments and coatings was written. This document is employed to invoke such treatment as Dow 17 anodic treatment for special alloys; cadmium plating with supplementary chromate and phosphate coatings; application of acid wash primer as a pretreatment to provide better adhesion of subsequent organic finishes; and special high-temperature paint finish for exterior surfaces to act as a corrosion deterrent prior to firing, as well as a modest thermal barrier against aerodynamic heating during the atmospheric portion of the trajectory.

5. An economical irradiated polyethylene wire jacketing has proved to be a very tough, but flexible, tempera-

ture-resistant and moisture-impervious insulation.

6. Embedding of sensitive miniaturized circuitry, to provide resistance to mechanical shock, vibration and corrosion, employs resin selected for its combination of mechanical, thermal, electrical and moisture-resistant properties. Epoxy, Thiokol and silicone resins are used extensively, depending on specific conditions.

7. Potting of electrical connectors against mechanical, vibrational, moisture-absorption and corrosive effects employs a Thiokol product with superior dielectric characteristics.

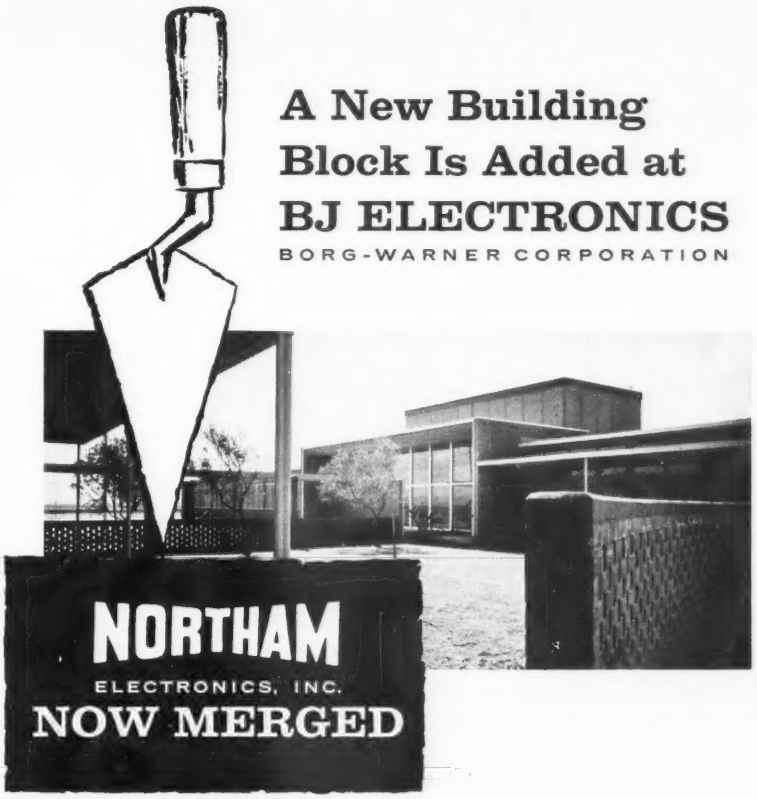
8. Silicone sealing compounds such as the recently developed EC-1667 and PR-1910 are used to thwart corrosion in seam and joint areas and simultaneously provide pressure sealing through the underwater launch and aerodynamic heating cycles. Optimum adhesion of this material is attained through use of a special primer, such as Dow Corning 4094.

9. An example of the use of a more unique material to combat corrosion under circumstances demanding excellent high-strength properties is the precipitation-hardened AM350 stainless-steel pressure vessel. In addition to excellent fabricating and mechanical properties, it displays corrosion-resistance in the hardened condition approaching that of conventional 18-8 stainless materials.

At first glance, the elaborate protective finish system, combined with the encapsulation approach, might appear to be somewhat redundant and unnecessary. However, it is possible to envision a situation wherein the encapsulating canister could be damaged in a severely corrosive marine environment and this damage perhaps go temporarily undetected. Under such circumstances, the finish system would play a major role in preventing undue deterioration.

In considering the nature of a weapon system wherein a submarine carries a ballistic missile for extended periods during which it may be called upon at a moment's notice and with minimum delay to launch the weapon unerringly to a remote target, it becomes apparent that the state of readiness must be constantly monitored by a system of electronic gear so impervious to corrosion-caused deterioration as to preclude any malfunction. It is also obvious that the continuous satisfactory functioning of such equipment is as important to the success of the weapon system as is the electrical and electronic apparatus designed into the missile itself.

Shipboard equipment enjoys some advantages over equipment incorpo-



A New Building Block Is Added at BJ ELECTRONICS

BORG-WARNER CORPORATION

Northam miniature magnetic tape recorders and recording systems, variable reluctance transducers, miniature accelerometers, airborne carrier systems, ground playback data reduction systems and special meteorological instrumentation are now available from BJ Electronics, Borg-Warner Corporation.

The Northam merger complements and extends the important group of products and services presently offered by BJ Electronics. Work backlog now transferred includes a USAF contract for high atmospheric wind sounding rockets, and further expansion of Northam multi-channel FM magnetic tape recording systems for missile nose cone flight test data acquisition.

Complete technical literature and the services of field engineering personnel are immediately available upon request.

Now—one source for all BJ Electronics and Northam products
BJ Vibrotron® Digital Transducers
BJ Radio-Frequency Test Instrumentation
BJ Data Measurement—Processing Systems
BJ Nuclear Instrumentation
Northam Miniature Magnetic Tape Recorders and Recording Systems
Northam Variable Reluctance Transducers and Miniature Accelerometers
Northam Meteorological Instrumentation
Performance and Environmental Testing

BJ ELECTRONICS BW BORG-WARNER

BJ ELECTRONICS
BORG-WARNER CORPORATION

Reliability you can count upon

3300 NEWPORT BOULEVARD, P. O. BOX 1679, SANTA ANA, CALIFORNIA
EXPORT SALES: BORG-WARNER INTERNATIONAL CORP., CHICAGO, ILLINOIS

TRANS-SONICS

T.M.

LARGEST MANUFACTURER OF TRANSDUCERS FOR TELEMETERING

introduces

TYPE 78
PRESSURE POTENTIOMETERS

FOR TELEMETERING AND CONTROL APPLICATIONS

shown ¾ size

- COMPACT — LIGHT — ONLY 6 OUNCES
- OUTSTANDING ENVIRONMENTAL PERFORMANCE
- HERMETICALLY SEALED MECHANISM
- STAINLESS STEEL CONSTRUCTION

Type 78 Pressure Potentiometers feature accurate and reliable performance under severe environmental conditions:

Sinusoidal Vibration: 1″ da, 2 to 22 cps; 25 g, 22 to 2000 cps

Random Gaussian Vibration: 0.1 g^2/cps, 15 to 2000 cps

Sustained Acceleration: 50 g on any axis

Mechanical Shock: 30 g on any axis

Operating Temperature: −65 F to +160 F with minimum change in output

Hermetic sealing protects entire mechanism against sand and dust, humidity, salt spray, fungus, and the fluid being measured. Unit has welded stainless-steel case, is 1⅞″ diameter by 1⅞″ long, weighs only 6 ounces. Standard ranges are 0-15, 0-25, and 0-50 psia; other ranges available.

Write to Trans-Sonics, Inc., Dept. 14, Burlington, Mass., for further information on Type 78 Pressure Potentiometers.

TRANS-SONICS

Precision Transducers

rated in the missile itself since less stringent size and weight restrictions in some instances permit greater latitude in selection of materials, parts and components from the viewpoint of corrosion resistance. The cooperation of BuOrd in providing access to extensive Navy experience in the protection of shipboard electronic gear has been an additional advantage. It must be mentioned, however, that the life expectancy of automatic checkout gear must be somewhat greater than that anticipated for the electronic components of the missile, since a single console installation must monitor repeated launchings over an extended service period.

The materials, parts and components invoked by design for fabrication and assembly of Polaris automatic checkout equipment display no significant deviation from the high quality normally required for ordnance shipboard electronic equipment construction. Surface-protected steel, aluminum, and corrosion-resistant steel enjoy considerable console and chassis applications. Potting and embedding compounds and resins, plus moisture- and fungus-resistant coatings, are used to prevent corrosive deterioration of electrical and electronic wiring, circuitry and components. Much the same resins, compounds and techniques are employed for the protection of the automatic checkout equipment as in the missile itself. The common phosphate and chromate conversion coatings, anodic coatings and electroplated finishes are, of course, used extensively as prepaint treatments and corrosion deterrents for checkout equipment hardware.

From the viewpoint of those whose experience stems largely from the need to meet past aircraft and missile industry contractual obligations other than those imposed by BuOrd, paint finishing requirements for naval shipboard equipment are rather unique. NAVORD OSTD-52 (Painting of Naval Ordnance Equipment) is a document which reflects the Navy's extensive background in the field of paint finishing for corrosion protection against marine environments. This standard provides access to a broad series of specially compounded paints and paint systems which have demonstrated an exemplary ability to forestall corrosion in marine environments. Paint finishing of automatic checkout and readiness equipment must conform to NAVORD OSTD-52 requirements in all instances where applicable.

The fact that the encapsulating containers are aimed at corrosion prevention does not obviate the necessity for preservation of such valuable and

These engineers are checking data as it is being acquired from a dynamic test. The results are being recorded on an oscillograph equipped with CEC's rapid-access DATARITE Magazine... DATARITE produces a flash-processed, dried, fully visible and permanent oscillogram in less than a second!

Use **DATARITE**

to monitor high-frequency, dynamic data visually

...as it happens!

To record, see, and analyze high-frequency data—instantly and simultaneously—CEC's 5-119 Recording Oscillograph and DATARITE Magazine provide the most efficient direct route to immediate access to test results.

In the test set up above, a DATARITE oscillograph and magnetic-tape recorder/reproducer are being operated in a time-parallel circuit. Input data fed to the tape unit are simultaneously recorded and processed by the DATARITE Magazine. Therefore, test results may be monitored continuously. Notations pertinent to the test, or references to later data-processing operations of the tape may be made directly on the DATARITE record as it emerges.

Sensitive galvanometers used in the oscillograph combined with DATARITE's high writing speed permit visual, instant monitoring of high-frequency data not possible with conventional pen-type recorders.

The 5-119/DATARITE combination provides a 50-channel capacity, greatly reducing the cost and bulk of equipment for application where immediate read-out is required.

For detailed technical information on the DATARITE Magazine and the 5-119 Recording Oscillograph, contact your nearest CEC sales and service office, or write for Bulletins CEC 1598-X22 and 1536-X27.

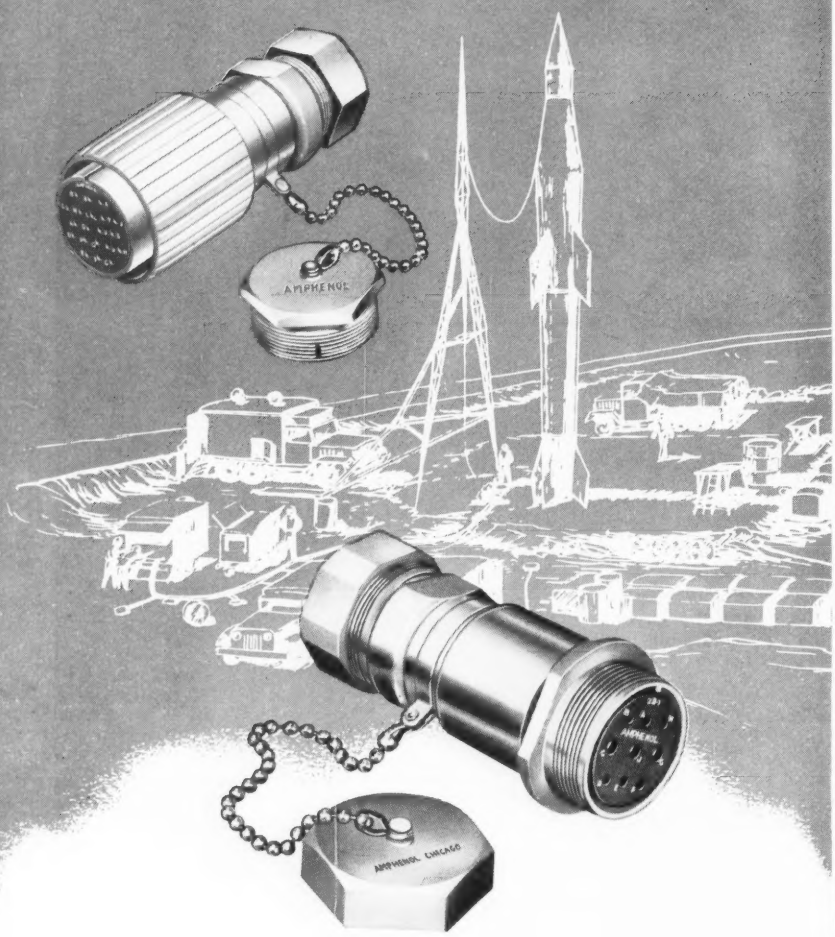
Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

FOR EMPLOYMENT OPPORTUNITIES WITH THIS PROGRESSIVE COMPANY, WRITE DIRECTOR OF PERSONNEL

RUGGED



GSE CONNECTORS

Connectors employed in Ground Support Equipment must be rugged and reliable—and easy to handle under any conditions. Fully meeting these particulars, AMPHENOL's popular 89 series GSE connectors are being used in many top missile projects.

GSE connectors are completely waterproof and provide dependable service even when submerged in mud, ice or water. An internal rubber gasket in the cable clamp, a type "W" washer at the mating faces and another washer used with panel mounting receptacles provide assured protection.

To facilitate handling in rough weather, coupling rings are extra-long and heavily grooved. Flats are conveniently located for field-servicing with standard open-end wrenches. Caps & chains are provided for all connectors.

AMPHENOL GSE connectors are available in a large number of standard "MS" inserts. Complete catalog data is available upon request.

AMPHENOL ELECTRONICS CORPORATION

chicago 50, illinois

AMPHENOL

specially designed equipment against corrosion. Use of these reusable items under conditions of rough handling and highly corrosive environments for extended periods makes it necessary to consider only the more durable finishes in combination with corrosion-resistant materials of construction.

The illustrations on page 39 show that air, rail and possibly motor carrier transportation is anticipated for Polaris and also serve to illustrate the wide variety of environmental conditions which may be encountered by the missile during transport. The extremes of temperature, pressure and humidity associated with air transport are, of course, minimized when pressurized cargo and troop transport aircraft such as the C-130 are employed. However, the possibility of use of other common, though unpressurized, cargo aircraft must also be considered. Shipment by rail naturally involves exposure of the external surfaces of the containers to the rigors of atmospheric weathering ranging from mild to extremely harsh.

Aluminum alloys such as 6061, 5083, 5052, etc., have been the most popular selection for canister material because of their inherent corrosion resistance in marine environments, their response to corrosion-preventive treatments, good strength-to-weight ratio, weldability, ease of fabrication, and ready availability at reasonable cost.

Here again reliance on the rugged proved finish systems available through NAVORD OSTD-52 is essential. The very nature of the activities of BuOrd has demanded highly durable packaging and containers for wide varieties of equipment which may be required to be shipped to and stored at depots all over the world. An examination of the content of NAVORD OSTD-52 discloses that high quality protective finishes for such containers constructed of all types of materials are available within its confines.

A typical completed encapsulating container and a portion of the attendant handling equipment is shown on page 38. Aluminum alloy 6061 was the predominant construction material here. Aluminum components received chemical film treatment and zinc chromate primer, plus the applicable top coating.

The importance of cleaning has not as yet been mentioned. Removal of organic and inorganic soils, weld flux residues, embedded particles, etc., is of prime importance prior to application of any corrosion protective treatment and finish, and, in fact, in some of the more delicate applications, such as the electroplated finishes employed

REPORT
On Ground FM/FM Equipment

New standards of performance are being set by Data-Control Systems telemetry ground stations now in use in missile and space research programs. These stations are meeting the needs of all three services — Army, Navy and Air Force.

The stations incorporate the most recent advances in telemetry science and are characteristic of DCS leadership in the development of new techniques and products. All units have been custom-designed with the exclusive DCS Data-Modules.

New Data-Modules

The DCS subcarrier disciminator is of the pulse-averaging type and incorporates the latest circuit techniques and components. Its performance is the best in its field. Among the features are an automatic input limiter, reduced sensitivity to changes in supply voltage and drift, chopper-stabilized output filters; and integral, completely automatic tape speed compensation circuits.

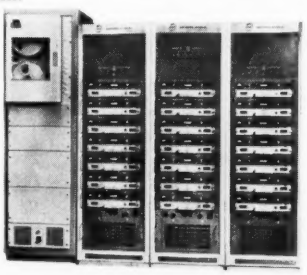
Switchable Tuning Unit

For use with the discriminator is the DCS switchable tuning unit containing modular switchable tuning units of 8, 16 and 24 channels. The unit gives maximum flexibility and compactness.

Ground Voltage Controlled Oscillator Assembly is Modular

This DCS unit and its associated modules includes frequency modulated oscillators, summing amplifier, reference oscillator, frequency-determining plug-ins and a common power supply which together form a complete FM tape recording system with maximum flexibility. Modules are available for all IRIG data.

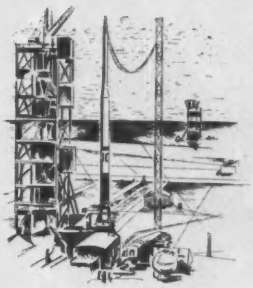
Write for full details to Data-Control Systems, Inc., 39 Rose St., Danbury, Conn.

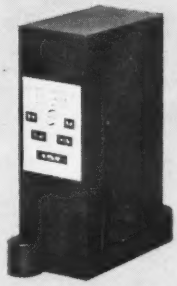


Typical ground station delivered to missile facility recently by Data-Control Systems, Inc.

Now — Setting the Standard of Performance in

AIRBORNE TELEMETRY EQUIPMENT





Model AOV-2S, G

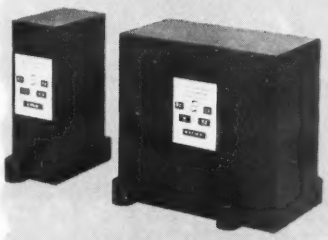
VOLTAGE-CONTROLLED OSCILLATORS

The AOV-2S offers a single power source 20 ma at 18 vdc ±20%. B supply variation of 10% produces less than 1% of bandwidth frequency shift. Temp. stability better than ±1%, 20°C-100°C. Long-term operable to 125°C. Distortion less than 0.6%. Shock 100 g, vibration 20 g to 2000 cps specified, tested to 55 g. Linearity ±0.5%, input impedance 500K. Drives most transmitters without a mixer amplifier. AOV-2G offers a lower price, comparable performance, reduced temperature range.

Model AOV-3S, G

The AOV-3S offers miniature size (approx. 4 cu. in.), single 18 vdc supply. B supply variation of 10% produces less than 2% of bandwidth frequency shift. Temp. stability better than ±3%, 20°C-100°C. Long-term operable to 125°C. Distortion less than 1%. Shock 100 g, vibration 20 g to 2000 cps specified, tested to 55 g. Linearity ±0.25%. Input impedance 100K. AOV-3G is same size at a lower price, comparable performance, reduced temp. range.

ELECTRONIC COMMUTATORS



Model APC-1

The APC-1 and power supply is all solid state, 75-900 samples/sec standard; other rates available. Commutator approx. 24 cu. in., 1½ lbs.; power supply 8 cu in.; 20 g at 2000 cps, 100 g shock. Noise less than 0.1%; random scatter between contacts 15 mv peak-to-peak; overall accuracy better than 1%. Temp. stability 0.25% 20°C-100°C. Input impedance ½ megohm plus parallel load.

OTHER AIRBORNE COMPONENTS

Strain gage oscillators, mixers and power supplies.

DCS **DATA-CONTROL SYSTEMS**

INCORPORATED
DANBURY, CONNECTICUT

Setting the Standard of Performance in Research Instrumentation

YOU DON'T HAVE TO BE A VISIONARY TO BE FAR-SIGHTED THESE DAYS

GENERAL

FILM LABORATORIES

ACHIEVES A DEGREE OF PERFECTION DESIGNED TO SATISFY THE CRITICAL REQUIREMENTS FOR THE RECORDING OF FLIGHT ON FILM. VALUABLE SCIENTIFIC DATA IS PROCESSED IN GENERAL'S MODERN LABORATORIES WHERE UTMOST CARE IS YOUR GUARANTEE. FOR COMPLETE 16mm AND 35mm SERVICES, INCLUDING THE FINEST 16mm COLOR PRINTING, CONTACT GENERAL FILM LABORATORIES

General Film Laboratories Corp. • 1546 Argyle, Hollywood 28, California • HO2-6171

for electronic mechanisms, almost antiseptic precleaning is necessary.

The viewpoints expressed here are not intended to reflect a static condition on the part of Lockheed Missile Systems engineers. A vigorous search is constantly going on for better materials, processes and finishes to provide the customer with the most deterioration-resistant product available in a highly competitive market. For example, some unusual techniques of plating, such as peen plating, vacuum deposition, organo-metallic and fused-salt baths, have been under investigation for some time.

Corrosion is costly. The decay and deterioration of materials in common structural applications such as bridges, buildings, plumbing, pipelines, storage tanks, machinery, etc., is a multi-million-dollar a year problem, with much of the expense involved absorbed by the individual taxpayer. A conscientious approach to the prevention of corrosion in a missile system like Polaris is thus vital not only from the economic point of view, but also because of the importance of maintaining our missile capabilities on a constant readiness basis.

IGY Rocket Mail Shoot Scheduled for Dec. 31

What is claimed to be the largest rocket mail demonstration attempted to date is set for Dec. 31, when the Rocket Research Institute of Glendale, Calif., will send six letter-carrying rockets across the Nevada-California border to mark the end of the IGY.

Some 6000 special rocket covers from stamp collectors will be aboard the 14-ft, 3-in. diam rockets, which will be fired from Clark County in Nevada to Nipton, a small mining town in San Bernardino County, Calif., two miles away.

The Institute is a nonprofit educational organization staffed on a part-time basis by engineers in the rocket industry. Harry Mueggenburg, an Aerojet design engineer, is chairman of its Rocket Mail Committee.

Fluorine to the Fore

Fluorine in present liquid propellant booster rockets would increase payloads by a factor of eight. This is how John L. Sloop, chairman of ARS Propellants and Combustion Committee, summarized the promise of liquid fluorine as an oxidizer at the ceremonials marking the opening of Allied Chemical's large-scale fluorine plant at Metropolis, Ill. The plant is expected to cut cost of fluorine by some 80 per cent.

how to handle a guided missile...

SPECIALISTS IN MISSILE HANDLING AND SUPPORT EQUIPMENT

research
development
production design
prototypes
testing
production

engineering to create the shape of things to come

WRITE FOR BROCHURE

WASHINGTON TECHNOLOGICAL ASSOCIATES, INC.

979 ROLLINS AVENUE • ROCKVILLE, MARYLAND

WTA

People in the news

APPOINTMENTS

Space Technology Laboratories became a separate subsidiary corporation of Thompson Ramo Wooldridge Inc. last month, following stockholder approval of the merger of Thompson and Ramo-Wooldridge. All of the divisions of R-W, with the exception of STL, are forming a single division of the new company called Ramo-Wooldridge, A Division of Thompson Ramo Wooldridge Inc. **Gen. James H. Doolittle** will become chairman of the STL board the first of the year, with **Louis G. Dunn** president and **Ruben F. Mettler** executive vice-president and general manager.

J. D. Thompson, former president of Thompson, becomes board chairman of the new Thompson Ramo Wooldridge Inc. **Dean Wooldridge,** former president of R-W, becomes president of the new merged group, with **Simon Ramo,** former vice-president and director of R-W and president of STL, becoming executive vice-president.

Harold C. Weber of MIT, a member of the Army Scientific Advisory Panel, has been named chief scientific consultant to the Army Chief of Research and Development.

Eugene J. Manganiello has been appointed associate director of the NASA Lewis Research Center (formerly NACA Lewis Flight Propulsion Center). **John C. Evvard** and **Bruce T. Lundin** have been appointed assistant directors of the Center, while **Walter T. Olson** and **I. Irving Pinkel** have been named special assistants to Center Director Edward R. Sharp. **Henry C. Barnett** has been named assistant to the director.

William O. Davis has been named executive head, Turbo Dynamics Corp. Space Technology Labs, Minden, Nev.

Maj. Gen. Leighton I. Davis has been appointed AF Deputy Commander for Research in a move to consolidate basic and applied research work.

Searle G. Nevius has been named as senior electronics engineer of Leach Corp.

Brig. Gen. Hollingsworth F. Gregory, commander of AFOSR, retired last month after 30 years of service. He was succeeded by **Col. Benjamin F. Holzman,** former assistant deputy commander for research at ARDC headquarters. **Col. Frank N. Moyers,** former vice-commander of AFOSR, has been named special assistant for policy in the ARDC Directorate of Development Planning.

United Research Corp. has been formed by United Aircraft Corp. as a wholly-owned subsidiary, with **Lt. Gen. Donald L. Putt,** new AF Scientific Advisory Board head, as president. URC will be headquartered at Menlo Park, Calif., and will operate primarily on a contract basis with other research organizations. **John Lee,** UAC research director, will serve on the new company's board, along with UAC president **William P. Gwinn** and chief scientist **Perry W. Pratt. Richard C. Soderberg** and **Guyford Stever** of MIT, **Isador Rabi** of Columbia Univ., **Bernard Lewis** of Combustions and Explosives Research, and **Allan Kline** of Sierra Metals Corp. have been named to the new company's scientific advisory board.

Former AF Chief Scientist **George Valley** has joined Melpar, Inc., Arlington, Va., as director of development planning. **Joseph V. Charyk** of Aeronutronics has succeeded Dr. Valley as Chief Scientist.

Thomas P. Higgins has been named to head R&D activities at Lockheed's Missile Systems Div. plant at Van Nuys. He was formerly missiles and space craft department manager in preliminary design at the company's Burbank plant.

Homer Joseph Stewart, professor of aeronautics at Cal Tech and chief of the Liquid Propulsion Systems Div. of Jet Propulsion Laboratory, has been appointed director of NASA's Office of Program Planning and Evaluation. **Walter T. Bonney,** has been named director of the Office of Public Information and **John Alvin Johnson,** former AF general counsel, becomes NASA General Counsel.

Robert E. Burroughs has been appointed director of the newly formed Univ. of Michigan Research Institute.

William C. House, director of Aerojet Systems Div., has been granted a one year leave of absence to serve with ARPA. In the interim, **C. A. Gongwer,** associate director of Aerojet's Systems Div., and also manager of the Underwater Engine Div., replaces him as acting director. **Marvin L. Stary** becomes associate director of the Systems Div., to assist Gongwer, and **Edward R. Elko,** chief engineer of Systems Operations. Other appointments are: **Thomas F. Rocco,** to manager of Aerojet's field service organization at the AF Missile Test Center in Florida, and **Col. William M. Frash** (Marine Corp.-Ret.) as customer relations manager for the Sacramento solid rocket plant. **Walter L. Tann** and **William O. Wetmore** have joined Aerojet as special assistants to vice-president-general manager, W. E. Zisch, and vice-president, Azusa Operations, W. L. Rogers, respectively.

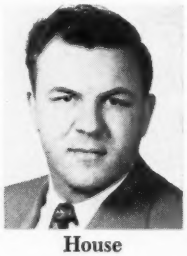
Boeing has named **T. A. Wilson** Minuteman program manager. He previously headed an advanced project proposal team in the Systems Management Office.

Charles E. Bartley, founder and president of Grand Central Rocket, has moved to Food Machinery and Chemical Corp., where he will serve as coordinator of rocket fuel programs and solid fuel development. **Cledo Brunetti,** vice-president of Grand Central, succeeds Bartley, who will continue as a board member, as president.

Bendix Aviation has appointed **J. M. Miller,** former assistant quality manager, director of engineering, Missile Section, in charge of Talos engineering design and development. **E. F. Lapham,** and **W. E. Worley,** have been promoted to assistant directors of engineering for the program. **Gerald C. Schutz,** former general manager, Gruen Industries Electronics Div. has joined the Systems Div. technical staff.

Aeronutronic Systems, Inc., has promoted **Ernst H. Krause,** former R&D head, to vice-president and general manager of the company's Computer Div., **Montgomery H. Johnson,** board member, to director of advanced research; **Roy P. Jackson,** former chief engineer, Northrop Div. of Northrop Aircraft, to general man-

Valley



House

Gongwer

Wilson

Miller

Dent

ager, Tactical Weapon Systems Div.; and **Arthur C. Haines,** former assistant to the Ford Motor Co. vice-president of manufacturing, assistant to the president.

Douglas Aircraft has named **J. L. Bromberg,** former chief project engineer for the Thor, to the new post of Thor weapon system manager. **H. M. Thomas** succeeds Bromberg. Top positions in the company's newly formed Minuteman Assembly and Test Div. have been assigned to **W. W. Benbow,** engineering manager; **J. W. Carroll,** manufacturing manager; **B. I. Maynard,** operations control manager; **J. H. Fried,** quality manager; and **H. A. Driver,** service manager. New assistant chief engineers in the Missile and Space Systems Engineering Dept., Santa Monica Div., are **M. W. Hunter,** space systems, and **C. S. Perry,** missile systems. **A. J. Carah,** has been upped to chief design engineer.

Maj. Gen. Frederick R. Dent Jr. (AF-Ret.), former vice-president of Electronics Corp. of America, has joined Martin's Baltimore Div. as manager of the Engineering Projects Dept.

Roy Healy, Rocketdyne program manager for the Jupiter engine, will also be in charge of the new program to provide a space-mission propulsion cluster for ABMA. In other Rocketdyne appointments, **David S. Haxton** has been made general superintendent of manufacturing; **David E. Aldrich,** program manager responsible for advanced large engine activity; and **Leif Skogstad,** chief facilities engineer.

Charles E. Hunter, former general manager, Hunter-Bristol Corp., has been appointed special assistant to J. W. Crosby, president of Thiokol Chemical Corp.

Schilling

Segerdahl

Complete service and production facilities for

GROUND SUPPORT
CRYOGENICS
NUCLEAR ENGINEERING

Stearns-Roger has for many years been devoted largely to design, engineering and building of various kinds of process plants. Our skills in high pressure piping, high strength concrete design, remote control and instrumentation inevitably led to Atomic Energy contracts and missile ground support work. Men of our Special Projects Department are cleared for the discussion of any variety of secret projects. We invite your investigation of our qualifications in Cryogenics, Nuclear Reactors, High Pressure Systems and complete base installations. Write for literature explaining our facilities, our background, our personnel, our ONE RESPONSIBLE SERVICE.

Stearns-Roger

THE STEARNS-ROGER MFG. CO. • DENVER, COLORADO

P. O. Box 5370 • Denver 17, Colorado

Martin Schilling, former chief, projects management staff, Research and Development Div., Army Ordnance Missile Labs, Redstone Arsenal, becomes programs manager and director of advanced development at Raytheon's Missile Systems Div.

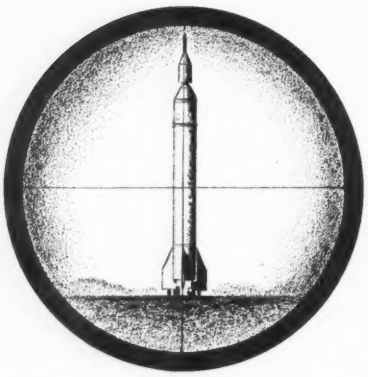
Capt. Hamilton O. Hauck, (Navy-Ret.), former director of Navy BuAer Guided Missiles Div., has been appointed director of the Fairchild Guided Missile Div. Technical Dept.

Robert F. Bacher, head of CalTech's Division of Physics, Mathematics, and Astronomy, director of the Norman Bridge Lab, and a member of the President's Scientific Advisory Committee, has been appointed a director of Space Technology Labs.

Roy Segerdahl, has been promoted from assistant chief engineer, Ford Instrument Co., to manager, Quality Control Div.

Clifford A. Sharpe, former vice-president of operations, American Bosch Arma Corp., has been appointed senior vice-president. **Ernest A. Goetz,** chief engineer, Arma Div., now will also act as technical assistant to the president.

Laurance U. Hurley has been named coordinator of test operations



OPTRONICS
BY
DAVIDSON

OPTRONICS—that science which combines the accuracy and perception of optics with the automatic control and readout afforded by electronics. In this field Davidson stands almost alone.

We are pioneers in the manufacture of Optronic controls for inertial and celestial guidance systems as made by the principal missile contractors of the United States.

We produce both experimental and proprietary Optronic instruments for both military and industrial end uses, some of which are:

ALIGNMENT TELESCOPES
AUTOCOLLIMATORS
AUTOMATIC ALIGNMENT COLLIMATORS
AUTOMATIC LONG AND SHORT RANGE AZIMUTH ALIGNMENT THEODOLITES
AUTOMATIC ELECTRONIC AUTOCOLLIMATORS
COMPARISON AUTOCOLLIMATORS
HENDRIX INTERFEROMETERS
INFRA-RED OPTRONICS
MICROSCOPES
MISSILE TRACKING TELESCOPES
OBSERVATORY MIRRORS
OBSERVATORY TELESCOPES
OPTICAL ELEMENTS
OPTICAL FLATS
PLANO INTERFEROMETERS
POINT SOURCE AUTOCOLLIMATORS
PRECISION DIVIDED CIRCLES
PRECISION SPECTROMETERS
RANGE FINDERS
TESTING APPARATUS

When you need the utmost in perfection and accuracy in optical instrumentation you will find it advantageous to turn to what may be the Free World's finest Optronic plant.

DAVIDSON
MANUFACTURING CO., INC.
2223 RAMONA BOULEVARD
WEST COVINA, CALIFORNIA, U.S.A.

of Marquardt Aircraft Co.'s Astro Div., with **John W. Cresse** supervising a new project management group in Astro's nuclear operation.

Carl S. Smith has been appointed executive assistant to the vice-president, Wyandotte Chemicals, and general manager of the Alkali Div. **Arthur C. Schubring** has retired as director of engineering, but will serve as a consultant on special projects.

James R. Brucker, Paul D. Burgess, and **Robert W. Ulrich,** former project engineers, Delavan Mfg. Co., have been promoted to senior project engineers in charge of the three sections of propulsion engineering.

Samuel Bousky, former director of engineering, Chicago Aerial Industries, has been appointed to the newly created post of chief scientist.

Robert D. Huntoon, a major figure in development of the radio proximity fuze, has been named to the newly created position of deputy director of the National Bureau of Standards.

Bruce A. Willsey, former plant manager, has been named vice-president and general manager of Solar Aircraft's Des Moines, Iowa, division.

Melville W. Robinson Jr. has been appointed chief engineer of Callery Chemical Co., and **Edward R. Arnold,** technical service representative in the Defense Products Dept.

Francis H. Lanahan, has been elected president of IT&T's newly formed International Electric Corp., resigning his office as president of Federal Electric Corp.

Airborne Instruments Laboratory, has formed a new Space Technology and Advanced Research Dept., under the direction of **W. E. Fromm,** with **J. Gregg Stepenson** as deputy director. The department is comprised of seven technical groups headed by the following managers: **W. R. Aylward,** advanced development; **W. B. Offutt,** equipment development; **A. J. Hendler,** ground support; **R. W. Graham,** data processing; **K. S. Packard,** reliability; **F. Tenenbaum,** subsystem integration; and **I. Ritow,** theoretical and operational analysis.

Comdr. A. J. Spriggs (USN-Ret.), vice-president in charge of Packard-Bell Electronics Corp.'s eastern operations, has been granted a leave of absence to act as adviser to the director of the Electronics Div. of the Business and Defense Services Administration.

John L. Kent, former editorial bureau chief, Consolidated Electrodynamics, has been named advertising and public relations manager of Datex Corp.

Malmstrom

Paige

Carl R. Malmstrom, has been promoted from assistant manager to manager of research and development and engineering of the Defense and Technical Products Div., Rheem Mfg. Co.

Rear Adm. James A. Thomas (USN-Ret.) has been elected vice-president of Kaman Aircraft Corp. He will direct the company's Military Operations Research group. **Robert A. Strieby,** former head of the group, has been appointed director of military relations for the Nuclear Div.

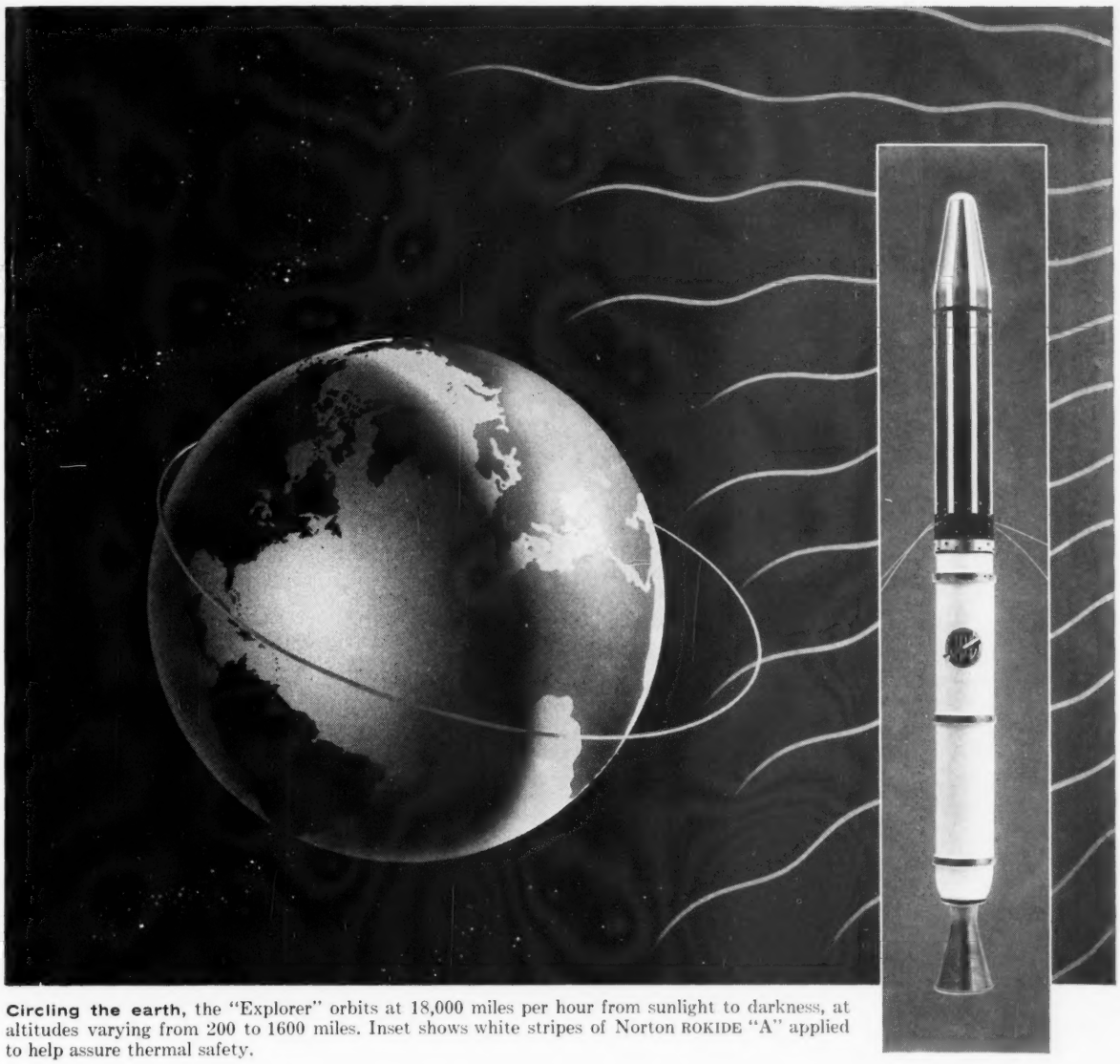
John H. Buck has been elected vice-president of engineering, BJ Electronics, Borg-Warner Corp., while **Donald R. Spotz** has been promoted from vice-president and general sales manager to president and general manager of the Pesco Products and Wooster Divs. of B-W.

Vitro Laboratories of America has named **William A. Bain Jr.,** former vice-president of VL and director of Vitro's West Orange Lab. (N.J.), to executive vice-president; with offices in Silver Spring, Md.; **Andrew J. Erickson,** former director of Armament Test Activity, to vice-president of VL, and general manager of Vitro Weapons Services at Eglin AFB; and **Edward W. Clarno,** to assistant general manager of VWS. **Arthur S. Locke** succeeds Bain as director of the West Orange Lab, and **Lewis H. Rogers,** succeeds Locke as associate director of the laboratory.

Richard L. Shetler, former manager of GE's Missile Guidance Section, will head the new Defense Systems Dept., Defense Electronics Div. **Hilliard W. Paige,** former manager of the Nose Cone Section, Missile and Space Vehicle Dept. has been named to succeed **George F. Metcalf,** as general manager of the department. Metcalf has been promoted to vice-president, defense activities, with headquarters in Washington.

DEATHS

Jack Wittgen, an ARS member since 1948, died recently. An engineer with Aerojet-General since 1943, his last position was superintendent of plant control at Aerojet's Azusa plant.



Circling the earth, the "Explorer" orbits at 18,000 miles per hour from sunlight to darkness, at altitudes varying from 200 to 1600 miles. Inset shows white stripes of Norton ROKIDE "A" applied to help assure thermal safety.

Hotter than Fire . . . Colder than Ice

ROKIDE* coating protects the "Explorer" through temperatures from 600°F to 150° below zero.

Completing its orbit every 118 minutes, the "Explorer" speeds between blazing daylight and black night every hour, through temperatures ranging from 600°F to 150°F below zero.

The resultant thermal risks, especially to instruments, are enormous. But by striping the satellite's nose cone and instrument section with ROKIDE "A" aluminum oxide spray coating, Jet Propulsion Laboratory scientists were able to maintain a safe internal temperature range.

ROKIDE "A", "ZS" and "Z" coatings are hard, crystalline refractory oxides. These Norton developments have high resistance to excessive heat, abrasion and corrosion that has proved valuable not only in reaction motors and AEC projects, but to general industry ..... in applications involving electrical insulation, electronics, bearing surfaces, erosion resistance, chemical barriers, material upgrading, surface catalyst activity and altering emissivity and characteristics of surfaces.

Facilities for applying ROKIDE coatings are maintained at NORTON COMPANY, Worcester, Mass., and at its plant 2555 Lafayette Street, Santa Clara, Cal. For the latest ROKIDE Bulletin write to NORTON COMPANY, 801 New Bond St., Worcester 6, Mass.

NORTON
NEW PRODUCTS

Making better products... to make your products better

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — **BEHR-MANNING DIVISION** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

Ike Sees Titan

President Eisenhower toured The Martin Co. Denver facility and saw this Titan during his pre-election visit to that city.

ASM Handling and Launching

(CONTINUED FROM PAGE 43)

proper tie-in of subsystems.

Missile flight test programs generally center about the engineer. Even during the latter stages of the Rascal program, it was apparent that system configuration was varying between delivery and flight. This is a natural outgrowth of the engineer's make-up and his desire for independent thinking. A malfunctioning electronic system will be attacked by the field engineer and made to work by some ingenious manipulation of a soldering iron and by tweeking and turning of potentiometers. This brings a requirement for the quality control man and, finally, close-up inspection procedures. These procedures, by the way, have proved to be invaluable as a double check in assuring that the missile is free of forgotten wrenches, electrical plugs are properly safety wired and cowling is properly installed.

Flight testing of Rascal and Shrike required setting up rather elaborate tracking systems on the Holloman test range. For analysis of performance, position data throughout the flight was required with as great an accuracy as the state of the art at the time would permit. Consequently, the missile was tracked by a network of Askania phototheodolites. Although these gave very accurate position information, completely reduced data were not available until several weeks after a flight took place.

Because of this delay, automatic tracking radars and plotting boards were used for immediate surveillance of the missile ground track and altitude profile. Accuracy requirements here were not stringent, but quick data were required to ascertain that the missile had not turned to a heading which might endanger towns and ranches within flight range of the test base.

Both tracking systems gave excellent results despite their complexity and the immense coordination effort required to man them. Scores of tracking operators, spread out over thousands of square miles of desert and mountains, had to work as a team.

Severe Restrictions

These two tracking systems imposed severe restrictions on flight test schedules. A high percentage of missions were cancelled because visibility was below the minimum required for the optical system, because manning of the many stations was not compatible with other projects being conducted on the test range, or because use of the radar system would have interfered with other projects. This restriction is not present in the operational weapon, of course, since there ground tracking is not required.

Radio voice communication was taken for granted at the inception of flight testing. It was assumed that the vhf radio system used for contact with the airport control tower operator would be used for coordination during missile launches. It became obvious early in the program that 100 per cent reliable voice communication was mandatory, and was not being obtained. Soon all aircraft and all ground stations were equipped with two complete sets of vhf equipment, and two channels were allocated for use of this program. All ground stations were also equipped with emergency battery supplies. Not until this was accomplished could the reliability of the communication system be taken for granted.

Later, when the Air Force shifted from vhf to uhf, all stations were re-equipped. Magnetic tape recordings of all transmissions served as a valuable source of data.

Once the communication system proved reliable, many uses for it developed. In order to position the aircraft in the most advantageous position for launching the missile, various navigation techniques were tried. The most successful turned out to be a ground-controlled flight pattern, directed by the operator of the ground radar plotting board. Steering information was given to the pilot by voice communication.

When B-47's carry the Rascal, the missile cannot be seen by the flight crew. Although nothing had ever happened to require direct observation of the missile, it was felt that an R&D program, with many advanced designs, should be conducted with at least one close-up observer and photographer. For this purpose, one or more chase planes were used which flew alongside the B-47 until the missile was launched. These observers were in radio contact with the B-47 crew and could warn them of the condition of the missile. On several occasions, the observers were able to advise the crew of hydraulic and fuel leaks so that the missile systems could be shut down before the situation became dangerous.

The voice communication system was relied upon to recall or hold a mission, sometimes seconds before the missile was scheduled to be launched. On several occasions observers at the telemetering ground station spotted malfunctions and were able to warn the flight crew in time to prevent launching of what would have been an unsuccessful flight.

Invaluable Communication

A valuable asset of the communication system was the opportunity it afforded for in-flight trouble shooting. When systems did not check out properly in the air, the flight crew was able to consult with experts on the ground, who often were able to devise procedures to define further the problem prior to return to base. On occasion, procedures were devised for curing or getting around the trouble, so that the mission could continue.

Last but not least, the voice communication system was an invaluable aid in keeping all the outlying photographers, observers, trackers, road blocks and recovery crews advised of the progress of the mission. These were all equipped with mobile two-way radio systems. Due to line-of-sight limitations, they could not all talk directly to each other, but all could communicate with the launching aircraft, which acted as a relay station in emergencies.

Elaborate precautions were taken with both the Shrike and Rascal to preserve the safety of towns and ranches bordering Holloman.

Since both missiles could conceivably fly off range into populated areas, they were equipped with destructive devices which could separate the missile into two unstable sections and terminate flight rapidly. This move could be initiated at either one of two tracking stations by means of a command signal.

The destruct system had two reliability requirements which were in some aspects contradictory. The system had to work when needed, yet had

the Pioneer in space

To send the U. S. Pioneer more than 60,000 miles to interplanetary space, Space Technology Laboratories in seven months designed, developed, assembled, and tested an 88-foot combination of three integrated stages with a payload incorporating 36 separate ignition systems. Astrovehicles Laboratory focused on the payload itself and the sensitively related problems of propulsion, weight, stability. These are in addition to the overall complexities of the structural configuration.

Pioneer, setting new apogees in science and missilery, typifies the achievements STL is making in the advancement of space technology. Those who are able to contribute to and benefit from these developments are invited to consider joining our staff.

Space Technology Laboratories

Space Technology Laboratories, Inc.
5730 Arbor Vitae Street, Los Angeles 45, California

to be built so as to keep from destroying the missile inadvertently. To fulfill the first requirement, two independent systems were employed; to satisfy the second, each system was designed with several safety devices in series, so that no one failure could result in destruction. In addition, other devices insured that destruction could not occur until the missile was launched and was a safe distance from the launching aircraft. At no time did this system fail to work when needed, nor was there ever an accidental destruct prior to launch.

The expedient testing of the ASM depends on this combination of systematic planning and versatile supporting equipment and procedures. Much of the complicated supporting activity falls away, however, as the missile becomes operational, and there remains a solid structure of refined handling and checkout equipment and instructions to see the missile into the field, and on target.

GSE Design Criteria

(CONTINUED FROM PAGE 35)

other packs on the MM-1 Truck.

The hydraulically operated crane mounts on and is powered by the truck. A storage pack which contains all the slings necessary to handle any item or pack in the weapons system also mounts on the MM-1. The crane can lift any unit in the Mace system.

Every well-integrated missile system must have a command, administrative and logistic communications system for coordinating the activities of the missile squadron. The Mace system provides hf and vhf radio telephone and radio teletype communications between squadron operational areas—i.e. command-operation-center area, relay and launch sites, and higher commands—as well as direct-wire telephone communications between groups in an area. This equipment operates from the MM-1 or from semipermanent ground installations. The equipment is standard but repackaged as necessary.

The test pack, mounted on the MM-1 aft of the power packs, contains three kinds of testers, only one of which is needed at the launch site.

One type is represented by the guidance-system test set, which is used by relatively skilled personnel for system adjustment, isolation of troubles to specific black boxes and periodic quantitative checking of guidance system parameters. The second type is represented by the basic missile checker (BMC) and an automatic powerplant checker (APPC), which make system tests of flight controls and the jet engine. The missile preflight tester is the third type.

Rapid Checkout Tool

The missile preflight tester (MPT) can be used by relatively unskilled operators as a rapid checkout tool just prior to launch. The main elements of the MPT are stimulus generators, programming devices, signal evaluators and display devices. The functions of the tester include starting the missile properly, performing automatically a series of tests of the complete missile and preparing the missile for launch. It also houses the launch-control panel and the control panel of the APPC, which shares the preflight test pack.

The MPT simulates flight from launcher to target, although, of course, it compresses the time scale for rapid checkout. Programming devices form the heart of the tester. For every test, the proper magnitudes and types of stimuli are chosen and proper missile-control signals are transmitted. The programmer also selects which missile responses will be monitored in any one step and determines the required mangitude, phase and tolerance of an acceptable response.

Since the purpose of the MPT is primarily to determine rapidly the readiness of the missile for launching, and to assure that no failures have occurred since precise testing with the various system testers, tolerances are rather broad except for certain critical voltages.

To increase its reliability, the MPT has a verification unit which, while running the tester through a normal sequence, gives a GO indication only if the tester puts out proper commands and properly evaluates the GO and NO-GO outputs from the verification unit.

Numerous circuits for the safety of both personnel and equipment are incorporated in both the MPT and APPC. Before a test can begin, the missile electrical system must be properly started through its automatic test sequence. After the missile goes through simulated flight, the last step of the test sequence requires the missile to be returned to the safe-to-fire prelaunch condition within a given time before a GO can be received. This circuit is monitored right up to the moment of firing.

Other safety precautions prevent the missile engine from being run up to launch speed or the missile launched until special interlock plugs are carried from the vicinity of the missile to the launch-control panel. Elaborate precautions are embodied in the circuitry of both the tester and the missile to prevent even the smallest chance of any kind of explosion at the launch site.

How, briefly summarized, does this system for Mace meet the design criteria? The whole system withstands extremes of environmental conditions, such as temperatures from −65 to 125 F, to achieve all-weather operation. Through the building-block principle, it offers minimum logistics problems. For example, one truck furnishes the prime power and mobility required by the complete weapon system. The entire communications system can be removed from the truck and operated from the ground, thereby releasing the truck for other needs.

Standard components, such as the truck engine and communications equipment, were used wherever possible for low cost and reliability. All equipment was designed for shipping in available aircraft. Mobility to the high degree required was achieved through the use of newly developed tires. Speed of operation and use of low-skilled operators was achieved through the use of automatic equipment and standard components.

In these and less prominent ways, the basic design criteria were utilized to provide the type of ground support equipment so essential to successful operation of a weapon system in the field.

Faster, Smaller Electronic GSE

Bell's Space Flight and Missile Div. recently showed this Analog Self-Checking Automatic Tester for checking electrical, hydraulic, and pneumatic systems of missiles and aircraft. The tester allows a single technician to check in 2 min a system previously taking 10 men an hour with conventional equipment. Developed for Rascal, it can be used with such ballistic missiles as Thor and Atlas.

Man-Machine Relationships a Growing Field for **OPERATIONS RESEARCH**

Mathematicians, Physicists and Engineers with experience or strong interest in Operations Research on large-scale automated systems will be interested in the major expansion program at System Development Corporation.

SDC's projects are concerned primarily with man-machine relationships in automated systems in a number of fields, including air operations. The application of new and advanced digital computer techniques is particularly important in optimizing these man-machine relationships. SDC activities constitute one of the largest Operations Research efforts in the history of this growing field.

Senior positions are among those open. Areas of activity include: Mathematics, Systems Analysis, Forecasts, Cost Analysis, Operational Gaming, Design Analysis, Performance Evaluation.

Those who have professional questions or desire additional information are invited to write Dr. William Karush, Head of the SDC Operations Research Group. Address System Development Corporation, 2400 Colorado Avenue, Santa Monica, California.

"A Theorem in Convex Programming." A paper by Dr. Karush is available upon request. Address inquiries to Dr. William Karush at System Development Corporation.

SDC

SYSTEM DEVELOPMENT CORPORATION
Santa Monica, California

An independent nonprofit organization

11-73

Missile Market

(CONTINUED FROM PAGE 48)

buyers. Let us examine that portion of General Tire's business that the investor is paying a couple of dollars for at the most.

Included in *this* $200 million volume are sales of:

Tires for autos, trucks, farm implements, airplanes, etc. The company is fifth among domestic rubber fabricators, and its tires go mainly into the replacement and fleet markets.

Plastic products, and other rubber lines, are also supplied to the automobile industry, which everyone knows to have been a disappointing customer in 1958. Expectations for the coming year are much better, however, and General's products are readily accepted by the industry.

General stock also gives the investor a call on another listed security, as the company owns 73 per cent of the voting stock of A. M. Byers, the world's largest producer of wrought iron.

Finally, General is becoming a growing factor in chemicals, and is also playing around with its RKO Teleradio subsidiary.

The company's business philosophy (and theory behind its diversification program which has sometimes led it pretty far afield from original basic line of products) is simple and effective. Quoting President William O'Neil, "We are in business to make money. If you build a big business you're a sinister influence; if you don't, you're a damn failure." Mr. O'Neil, by the way, has more at stake than just his salary in putting this philosophy into practice, since his family owns 20 per cent of the common stock of the company (current value of their interest—approximately $30,000,000).

To summarize: At present prices, General Tire is selling at just about its equity in Aerojet-General alone, with no allowance for its promising outlook in rubber, plastics, and chemicals. Its basic position in each of these fields has been strengthened significantly by recent programs which have added to production facilities (programs which have also affected earnings adversely, and which are now completed). Cash earnings next year (before depreciation and other bookkeeping charges) should total $8 per share, with reported net earnings around the $2.50 level. Future years should see a considerable increase in these figures. Although current yield is low, the company has paid continuous dividends for 20 years, and currently supplements its cash distribution with small stock dividends. Cash rate should be increased in fiscal 1959.

In addition to its common stock, General Tire has outstanding just about every type of equity security known to investors—a convertible preference stock, two other issues of straight preference securities, and three types of common-stock purchase warrants. Since most of these issues sell at pretty close parities to each other most of the time, however, the average investor is just as well off just buying the common, which is listed on the New York Stock Exchange.

International Scene

(CONTINUED FROM PAGE 14)

It was decided at Amsterdam that sufficient consideration could not be given by the Council of the IAF because of lack of time and the announced determination of some member societies that no current action would be acceptable and that reorganization should be studied during the interim before the 10th IAF Congress in London next September.

* * *

While the resolution to grant recognition to the IAF did not carry at the Executive Board meeting, the writer urged further consideration of the matter by the General Assembly itself. An Assembly Committee was then appointed which reported favorably and the ICSU-IAF resolution quoted above was unanimously adopted.

* * *

The best and most succinct report on the ICSU Committee on Space Research appears in official actions of the Executive Board, quoted verbatim: "Recognizing the need of an International Committee on Space Research and considering that ICSU should continue its work of coordination in this field, there be established an ICSU Committee on Space Research to function until the end of the year 1959 as follows:

"The primary purpose of the Committee is to provide the world scientific community with the means whereby it may exploit the possibilities of satellites and space probes of all kinds for scientific purposes, and exchange the resulting data on a cooperative basis. It shall further report to ICSU these measures needed in the future to achieve the participation in international programs of space research of all countries of the world with those which are already actively engaged in research programs involving the use of instrumented earth satellites and space probes.

"The Committee shall hold as a primary objective the maximum development of space research programs by the international community of scientists working through the ICSU and its adhering national academies and unions. Recognizing, however, the need for international regulation and control of certain aspects of satellite and space probe programs, the Committee shall keep itself fully informed on UN or other international activities in this field, in order to assure that maximum advantage is accorded international space science research through such regulations, and to make recommendations relative to matters of planning and regulation that may effect the optimum program of scientific research.

"The composition of the Committee is as follows:

(a) A representative from each of the countries which are actually launching earth satellites, as also of those having major programs in rocketry.

(b) Three representatives, designated on an agreed system of rotation, from among countries actively participating in tracking and other aspects of space research.

(c) One representative each from the following Unions: IAU, IUGG, IUPAC, URSI, IUPAP, IUBS, IUTAM, IUPS, and IUB.

"A Convenor will be designated by the Bureau of ICSU, whose duty it will be to call a first meeting of the Committee:

(a) To formulate a charter of responsibilities and a detailed organization for the conduct of its affairs, to be submitted to the Bureau of ICSU for approval.

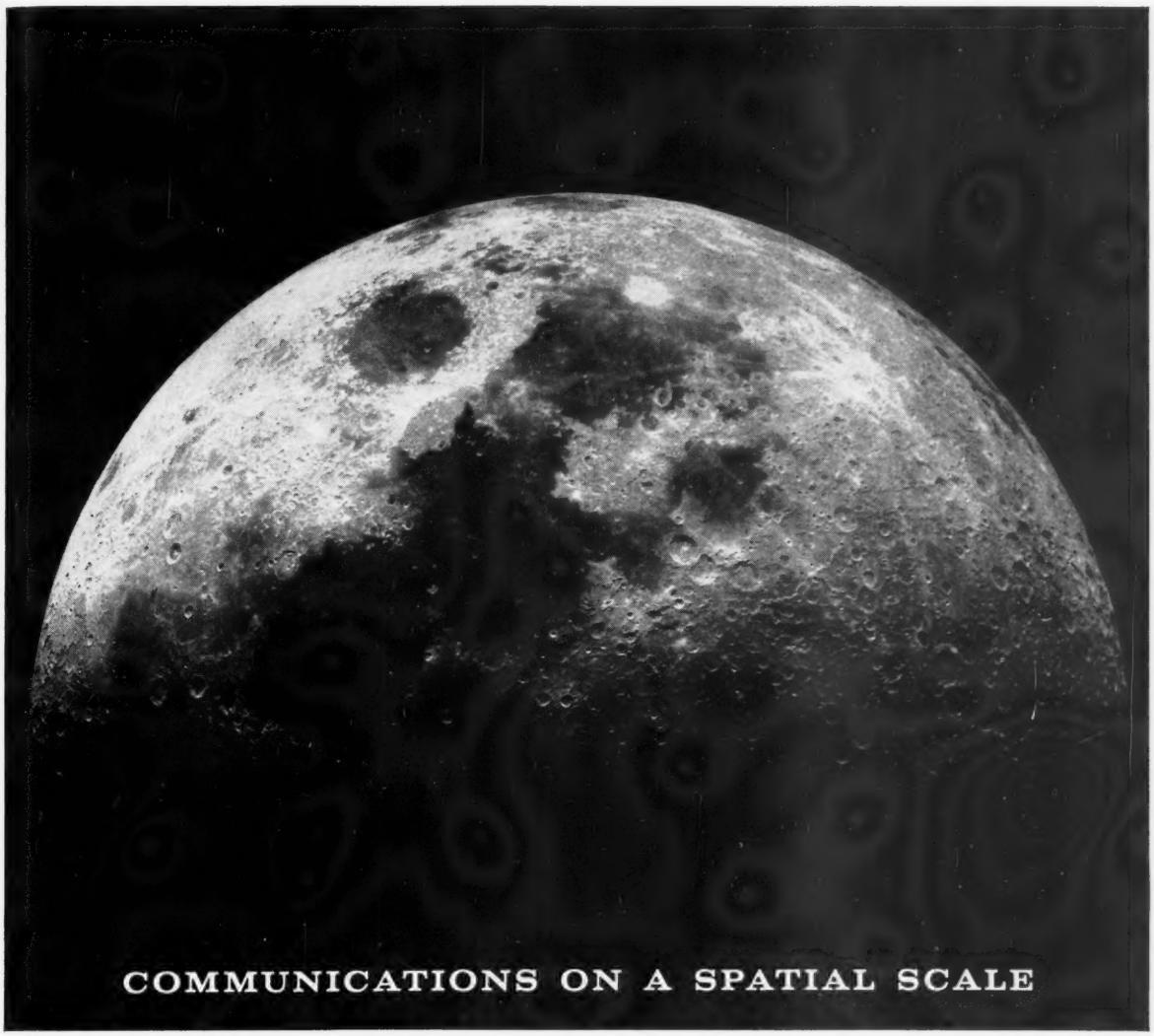
(b) To elect from among its members an Executive Committee of not more than five members, such Committee to include representatives of countries actually launching earth satellites.

"The Committee on Contamination by Extra Terrestrial Exploration will report its conclusions to the Committee on Space Research.

"The Bureau of ICSU is directed to arrange the adherence of as many countries as possible."

* * *

It is now up to the IAF member societies to determine, within the next few months, whether the Federation will pursue the matter further by agreeing to amend its constitution to create the three divisions recommended by the von Kármán committee in Amsterdam and by arranging in the meantime to cooperate with the Committee on Space Research.



COMMUNICATIONS ON A SPATIAL SCALE

"SHOOTING FOR THE MOON" at the Hughes Communications Systems Laboratories is more than just a figure of speech—it's an actual goal.

The Communications Laboratories have as one long-range objective the development of communications systems capable of deflecting their signals from meteors, artificial satellites and even the moon. Yet another is the development of systems which transmit intelligence through media impervious to radio frequencies by modulating frequencies far up in the electromagnetic spectrum—light, even gamma rays.

An example of advanced Hughes methodology is the use of digital techniques to overcome the mutipath phenomenon—the tendency of radiations to be resolved by different layers of the ionosphere or other reflectors into two or more signal paths. Under certain circumstances, this situation in the past has produced a confused signal.

To extend its projects into advanced new areas, the Hughes Communications Laboratories must be staffed with engineers and physicists of high professional stature. Openings now exist for such personnel, and the salary structure will reflect the exceptional background required. Your inquiry is invited. Please apply directly to:

Dr. Allen Puckett, Associate Director,
Systems Development Laboratories.

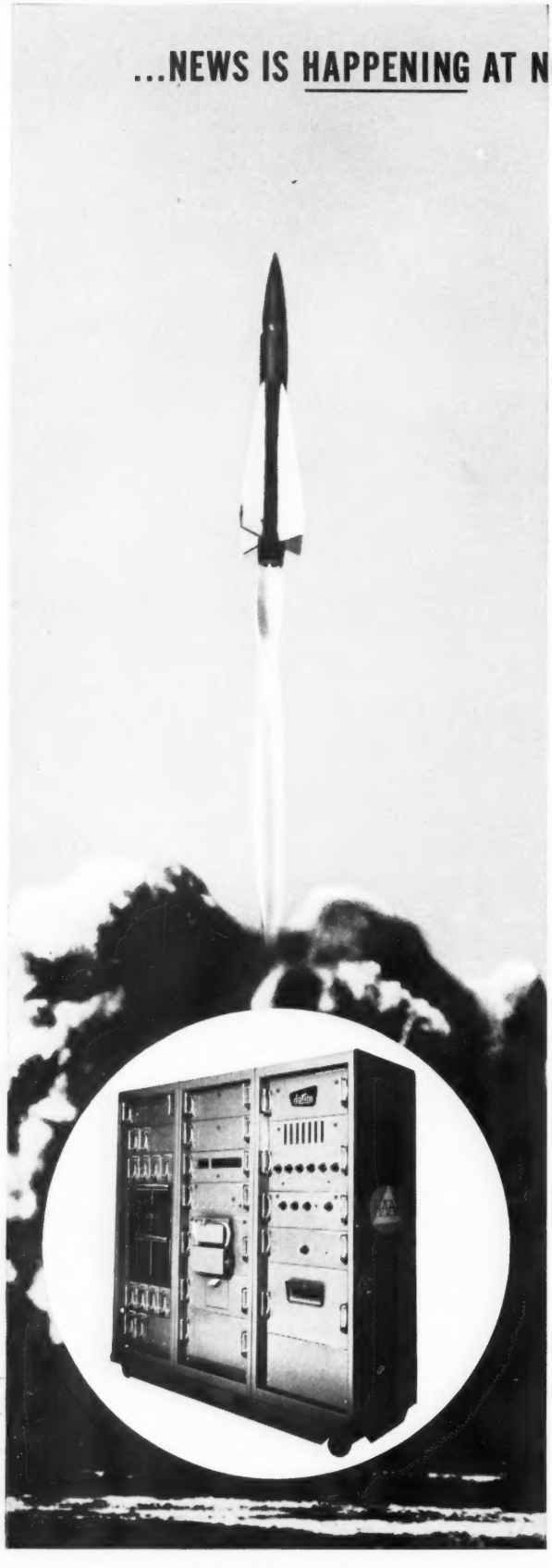
the West's leader in advanced electronics

HUGHES

Hughes Aircraft Co., Culver City 29, Calif.

© H. A. C.

...NEWS IS HAPPENING AT NORTHROP



OPERATIONAL NOW! NORTRONICS UNIVERSAL DATICO TO CHECK OUT ADVANCED MISSILE SYSTEMS!

READY NOW! The first and only universal automatic checkout equipment in production is Nortronics' Universal Datico. Standardized, self-checking test equipment, readily adaptable to any missile system or group of systems, Universal Datico is a single system of automatic evaluation equipment available for support of advanced operational missiles. Other production contracts include checkout applications to U.H.F. equipment and autopilot sub-systems.

PERFORMANCE PROVED. Datico has logged thousands of hours of reliable performance during which its speed and adaptability from one system to another have been demonstrated. Its rapid, unerring, Hi-Go-Lo evaluation of existing systems indicates its applicability to future systems as well as to today's. It quickly locates malfunction of the system or any sub-system element down to piece parts and records its findings on printed tape.

TIME–MANPOWER–DOLLARS. Datico saves all three. No need for costly, time-consuming research and development. Datico is available now for today's requirements. Application of Datico to your problem can mean savings up to 75% in manpower plus a dividend in reduced skill-levels required; savings up to 90% in checkout time; and 50% in acquisition cost.

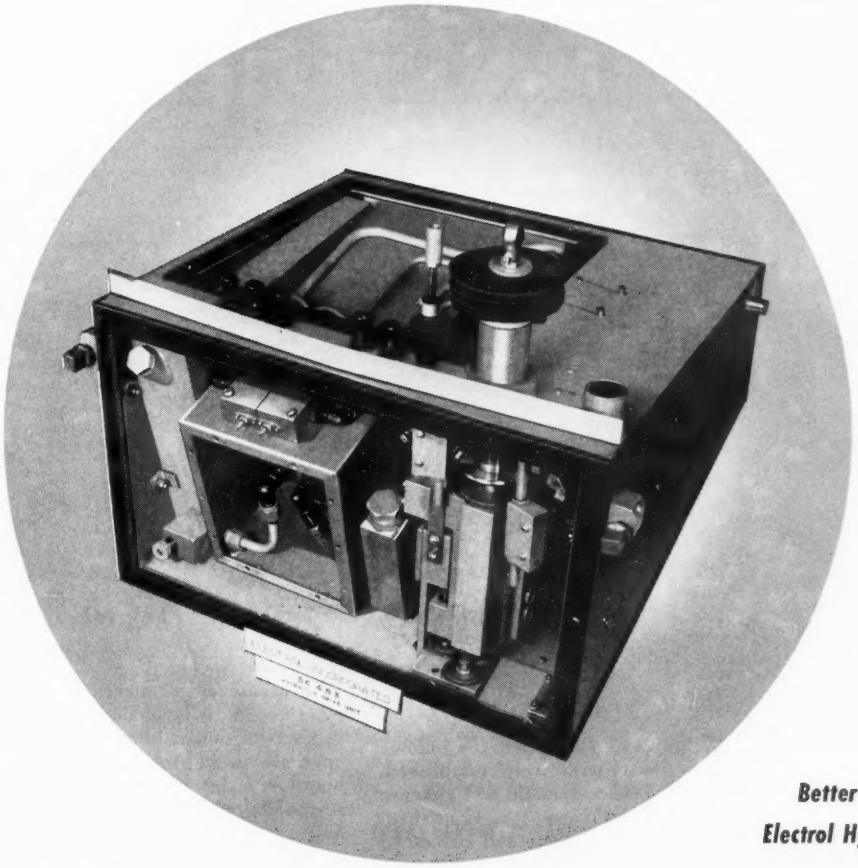
TOMORROW'S DATICOS–Nortronics' continuing development program, combined with the management and engineering foresight which created Datico in time for today's weapons, is now developing advanced Daticos for tomorrow's weapons. These new checkout devices will incorporate even greater speed and such features as evaluation of total system degradation without sacrificing reliability and relative simplicity.

If you have a checkout problem...if you have checkout requirements for any system or level of a system, call Nortronics today, or write Chief Applications Engineer, Dept. 2003-H Nortronics, A Division of Northrop Aircraft, Inc., 500 East Orangethorpe, Anaheim, California.

NORTRONICS
A Division of Northrop Aircraft, Inc.

Electrol Hydraulic Power Packages

for Missile, Ordnance and Industrial Applications



Electrol self-contained hydraulic power packages develop and transmit the hydraulic power required to actuate the mechanisms of missile loaders, launchers and surface controls . . . radar antennae . . . and industrial applications. Units are custom-designed to meet specific requirements as to envelope, weight, pressure and flow.

Better Designed Products Use Electrol Hydraulics and Pneumatics

Typical Electrol Hydraulic Power Package, including electric motor, power pump, reservoir, directional control, relief and speed control valves.

- **One Source Service**

Avail yourself of Electrol's complete service for designing, engineering and manufacturing of hydraulic components and complete hydraulic systems.

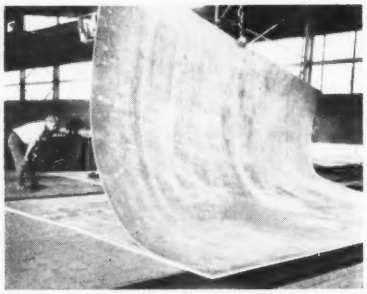
NFPA NATIONAL FLUID POWER ASSOCIATION

Electrol

INCORPORATED

KINGSTON, NEW YORK

Widest Pack-Rolled Steel



Lukens Steel "pack-rolled" this 160 by 192-in. sheet of high-strength steel as the prototype material for giant solid propellant rocket cases. Sheet is one-third wider than any produced previously by pack rolling.

Universal Test Systems

(CONTINUED FROM PAGE 33)

heels of Fact One. A decision element of some nature—something that would decide if a measured value was within tolerance, or high or low—was mandatory. Fact Three came to light in a flash of genius when a lazy engineer decided that a machine could print the measured value and thus provide a permanent historical record. The decision element could readily instruct the printer to shift a ribbon from black to red to record an off-normal value.

An operator could master the array of knobs, switches and indicators and might, with much practice, conduct a consistent test procedure. A mistake, however, could be quite costly. Several other facts became apparent. Operators were hard to train and tended to become bored with routine test duties. When a crisis occurred, operators would lose control and wreak havoc in a conscientious effort to race the automatic weapon system equipment. The more the operator knew about the dangers involved, the more pronounced his panic. After such crises, long hours of discussion would fail to disclose what had happened and what human errors had been committed.

With this much enlightenment came the realization that the equipment had to be automatically programmed. There was the usual indecision over using magnetic tape, perforated cards or perforated tape. There had been prior experience with semi-automatic stepping switch sequences, and it was realized that a more flexible input was mandatory. As a result of careful consideration of the state of the art, reliability, economy and process time requirements, the perforated tape program was selected. Today, perforated mylar-paper tape is a popular program input medium.

At this point in time, another important decision became necessary. Airborne automatic control systems had gone through the magnetic amplifier phase and were well into the transistor phase. Much progress had been made in replacing vacuum tubes with transistors. The factors of space and reliability were of prime importance. On-off switching was still relegated to the hermetically sealed relay.

Should we plunge headlong into the new art of solid-state switching and try to accelerate the development by sheer application of manpower and dollars, or should we stay in the known area of the stepping switch and the relay for on-off switching and keep abreast of the transistor technology in the conventional application of the contemporary state of the art?

A decision was made to continue in sound engineering practice, since mass production of equipment for delivery to the customer was of paramount importance in our particular programs. While adequate development was funded in the area of solid-state transistor switching, the bulk of the development hours and hardware dollars went to developing a medium-speed, tape-programmed stimulating, measuring, comparing and recording unit.

Design Criteria Established

With this in mind, then, the following design criteria were established for a universal automatic test system:

1. *Trustworthiness.* Consistent with development time and economy, the system must be trustworthy. It must never—well, hardly ever—fail. When it does fail, an immediate warning must be given. The system must not, under any circumstance, give a wrong answer.

2. *Ease of Maintenance.* The system must be easily and rapidly repairable. No special tools should be required. It must have self-testing and self-checking capability.

3. *Ease of Calibration.* Self-calibration must be provided, based on secondary standards contained with the system. Calibration can be automatically employed at regular intervals or prior to critical tests.

4. *Flexible Programming.* The system must be highly accessible for program change. Not only must it be capable of changing from system to subsystem to module, but it must be capable of interweapon system application. (Of equal importance is a serial number-type change within a system, subsystem or module where the 50th part made differs from the 49th.)

5. *Proper Operating Speed.* The operating speed of the test system must be compatible with the process time of the equipment under test and the versatility of the test schedule.

On tests of a varied nature, it is uneconomical to provide high-speed capabilities if large delays are encountered in setting up memory units to run a rapid test sequence. On repetitive testing, where the memory can be changed once and used many times, the cost of such a high access speed memory can be regained in time saved. It is interesting to note that, on most tests, more time is required for connection and system warmup time than is required for performance of the actual test.

6. *Environment Suitability.* The test system must be suited to its environment. It is obviously foolish to attempt to operate factory or depot type equipment from the back of a jeep in a sand or rain storm. It is equally foolish to encumber factory or depot equipment with the safeguards needed for operation in difficult environments. The modules can well be standard and interchangeable. The housing of these modules should be adjusted to the environment.

7. *Reasonable Cost.* Costs must be evaluated on a reasonable base. A costly feature that is seldom used should be included only when no other means are available. Each expenditure must be evaluated in terms of hours or dollars saved. A prodigal approach in an area where dollars or hours can be saved will result in severe limitations in other areas where large expenditures are both warranted and necessary.

8. *Multi-Level Operation.* Every consideration should be given to using the same equipment, properly housed or contained, in several levels of operation. The equipment designed for use in a conventional building is frequently highly useful in a wheeled van in field use. When hour and dollar costs are compared, the cost of a standard van is frequently far less than the cost of special environmentally controlled enclosures.

9. *Wide-Range, Multi-Purpose Stimuli.* Every test at every level requires some form of input. Careful consideration should be given to providing wide-range, readily programmable power supplies, signal generators and conversion equipment. Space, hours and dollars are all affected in this area.

10. *Simplicity.* An infrequently recognized booby trap can be found in any development program. Simplicity is difficult to achieve. Elec-

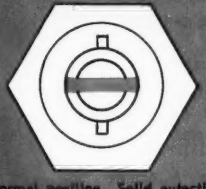
THE MARK OF QUALITY

BARBER COLMAN

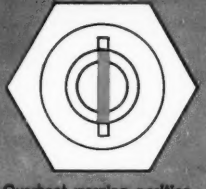
Aircraft Controls

new, small-size overheat indicator shows where to head off major trouble before it happens!

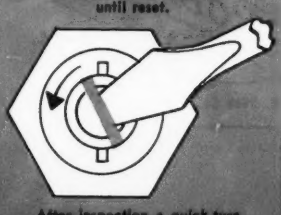
Typical mounting detail. Eutectic metal in probe melts at given limit, releases indicator to warning position.



Normal position. Solid eutectic holds indicator here until overheated.



Overheat warning position. Indicator remains here until reset.



After inspection a quick turn

provides quick, visual post-flight ground checks for overheat conditions

Overheat conditions may come and go on an aircraft, or possibly be overlooked and unrecorded during a flight. But with Barber-Colman overheat temperature indicators on the craft, the ground crew has positive proof of critical temperature conditions, and their locations. The indicator illustrated here was recently developed to detect and indicate overheat in the engine oil temperature of a jet bomber. Set before flight, the indicator remains at "normal" until the oil temperature exceeds 275±5° F. After landing the aircraft, a quick glance at the indicator position reveals if the engine has overheated. Designed primarily for indicating temperatures of fluids, Barber-Colman overheat indicators can also be used for air. They can be supplied with properly proportioned eutectics to react at the temperatures required by your applications and can be mounted at any inspection point on an aircraft. Weight of unit shown is .10 lb. Call your nearest Barber-Colman engineering sales office, or write direct for data.

BARBER-COLMAN COMPANY

Dept. L, 1494 Rock St., Rockford, Illinois

Aircraft Controls • Electrical Components • Small Motors • Automatic Controls
Industrial Instruments • Air Distribution Products • Overdoors and Operators
Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

tronics engineers rely on the cut-and-try process to improve a design or product. An innovation frequently engenders complications resulting in a setback to the program. These setbacks are generally overcome, but frequently only after introducing strong and deteriorating transients in the development program.

In view of these criteria, it becomes apparent that proved techniques based on the contributions of many organizations and engineers should be used. Pioneering is a must, but should be launched from a firm engineering base and then only when the results justify the risk. Today, the military wants an operable test system, and not an experimental one. In most areas, less sophisticated methods are acceptable if they are reasonable. In areas where sophistication and a degree of risk is involved, reckless abandonment to unqualified techniques can only result in lack of confidence in industry on the part of the military, and deterioration in the reliability and effectiveness of the entire system.

The requirements discussed here are not paper requirements, but real operating requirements. Equipment has been designed, developed and built by Nortronics to these philosophies and requirements. Experimental units have operated for thousands of hours of cumulative factory and depot use. Complete systems have been built and applied to such missile systems as Snark, Nike and Sergeant. Subsystem testing of communication equipment is now under contract with the Air Force. A contract is in the works for delivery of a prototype universal test set to the Army for use in testing the Hawk, LaCrosse, Sergeant, Corporal, Dart, Nike-Ajax and Nike-Hercules missiles. This contract has funded programs for system, subsystem, module and piece-part testing. These tests have been highly successful.

In other words, automatic universal test sets, well within the limits of today's state of the art, are already a reality.

Polaris Data System Completed

A combination data processing and closed circuit TV system for the Polaris IRBM has been completed by Siegler Corp.'s Hallamore Electronics Div. under a $1 million Navy contract. The phase-lock principle is employed in the system, first ever developed for static missile testing as well as actual launchings.

Atlas Handling

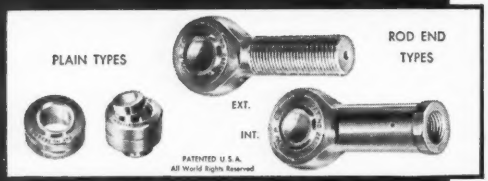
(CONTINUED FROM PAGE 23)

minimize stresses on support points that would be caused by eccentric loads.

The launcher must hold the missile, loaded or unloaded, upright in winds up to 60 mph. It must also permit controlled release of the missile *after* the rocket engines have attained the proper amount of thrust, not before. The main support system of the launcher consists of two pin-ended arms which fit into sockets on the missile and which bottom solidly in the down position. They are restrained from moving upward by 8000-psi pneumatic cylinders designed to resist the thrust of the three booster and sustainer rockets. When these three engines have attained full thrust—something less than 3 sec after ignition—these cylinders provide a smooth, controlled rise-off of a few inches by means of an orificed blowdown system.

During early stages of launcher design, it was felt there might be some difficulty in having these cylinders blow down at exactly the same time and rate. Consequently, relatively elaborate means of testing the blowdown system were devised. During the entire flight test program, how-

"MONOBALL"®
Self-Aligning Bearings



CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. **Dept. AST-58.**

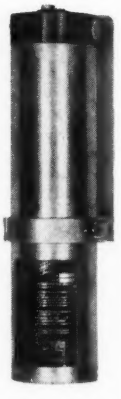
SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

DEHYDRATION OF GASES
PRESSURES UP TO 12,000 PSI

New Leakproof Design — Chambers and Cartridges "O" Ring sealed, no possibility of gas bypassing the cartridge.

No tools required to change cartridge or Mechanical Filter Element for cleaning.

Manual or Automatic Units. Portable, stationary or airborne installations.

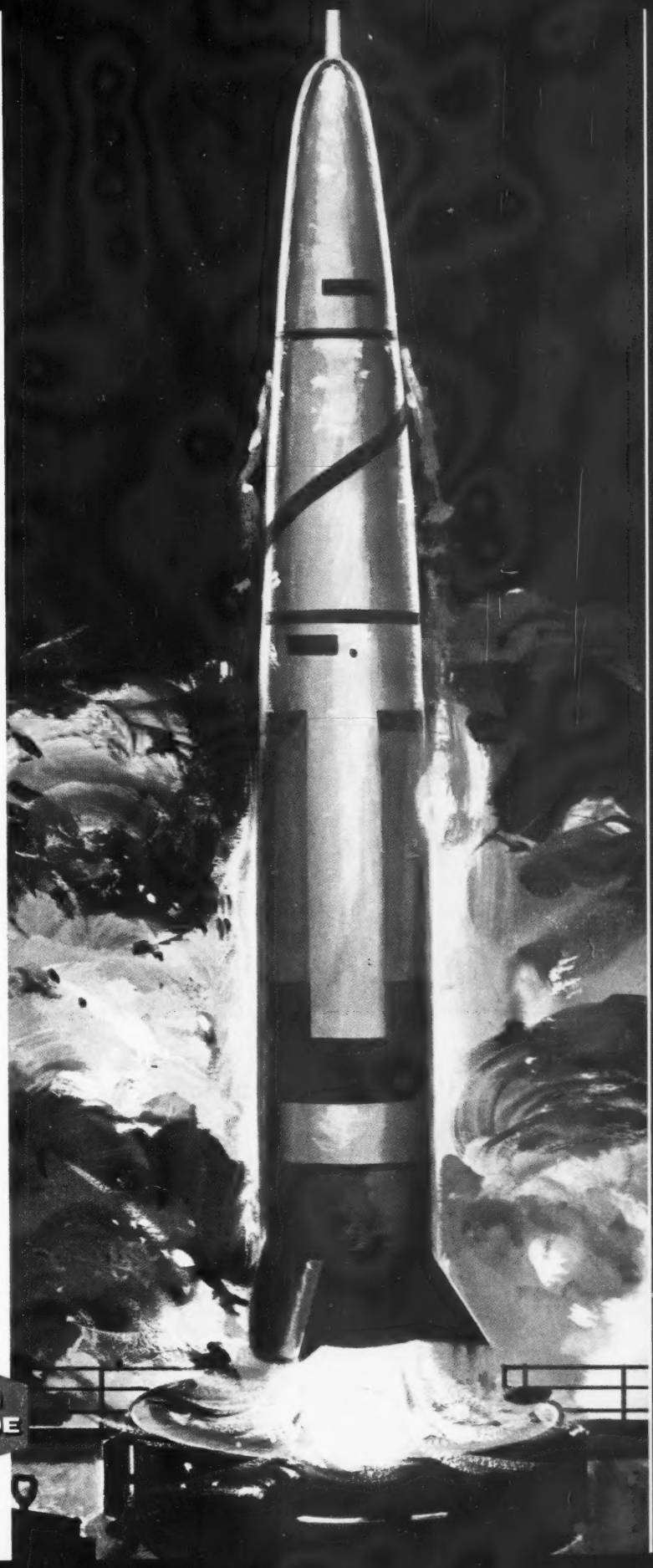


WRITE FOR DETAILS

ROBBINS Aviation, Inc.
2350 E. 38th St., Los Angeles 58, Calif.

THERE
IS
NO
BETTER
WAY
THAN
WITH

LIQUID OXYGEN



Liquid oxygen is the safest, most efficient oxidizer commercially available for missile and rocket propulsion systems. It is stable, non-toxic, non-corrosive, and easy to dispose of when necessary. That's why it is used in IRBM and ICBM motors.

Large volumes of liquid oxygen can be stored indefinitely in LINDE designed and built storage units – right where it is needed. Vaporization losses are minor – can be held to *less than 5 per cent per year.*

Using LINDE's methods, liquid oxygen can be transferred safely from storage – without pumps – ten times faster than previously.

LINDE can supply large quantities of liquid oxygen almost anywhere in the nation—quickly, and at a cost of only pennies per pound.

If you are concerned with the nation's vital missile and rocket development program, take advantage of LINDE's more than 50 years of experience in producing, transporting, and storing liquid oxygen. Call the LINDE office nearest you, or write: LINDE COMPANY, Division of Union Carbide Corporation, Dept. AA12, 30 East 42nd Street, New York 17, N. Y.

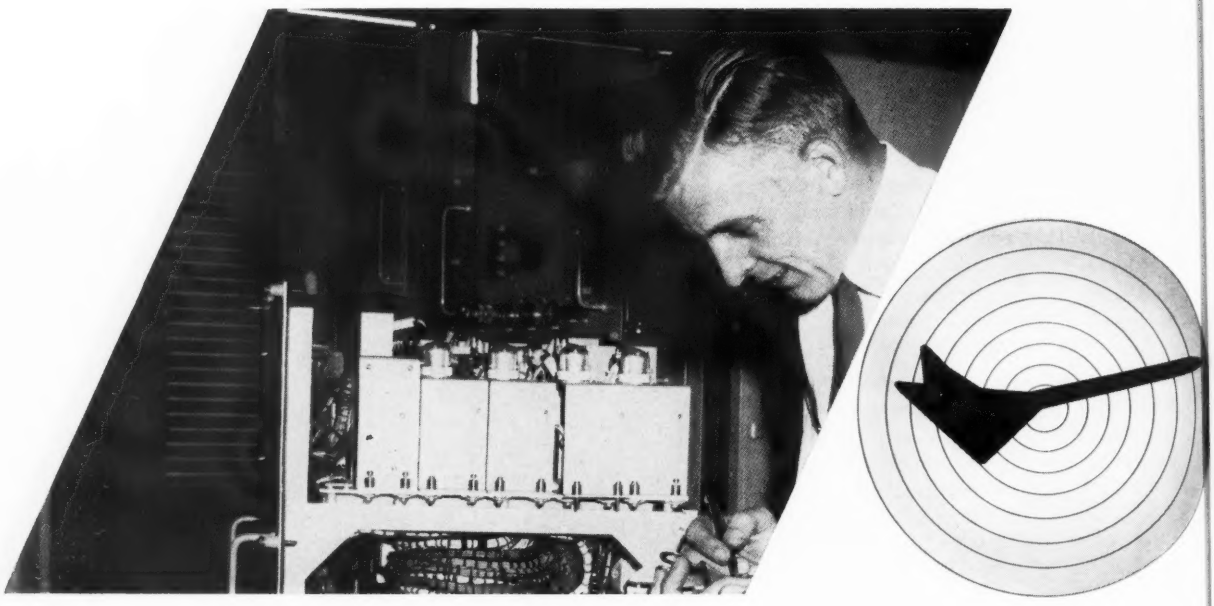
Linde
TRADE-MARK

UNION CARBIDE

"Linde" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TEST EQUIPMENT ENGINEER John W. Li tells why his work in the B-70 weapo system at **IBM** Owego affords him the c ative engineering career he always want

what's it like to be a creative engineer at IBM?



Assignments now open include...

MAGNETICS ENGINEER to design and analyze magnetic core circuitry for use in advanced digital computers. Assignment entails application of these circuits to logical connectives and systems.
Qualifications: B.S. or Advanced Degree in E.E. or Engineering Physics and 2 to 5 years' experience with magnetic circuitry. Must be familiar with fundamentals of non-linear magnetics and have strong interest in logical circuit application of magnetics.

PACKAGING ENGINEER to undertake development and design of packaging techniques and mechanical design of electronic equipment; to investigate temperature effects on packaging; to offer design support to computer, radar, and inertial development groups; to analyze present and proposed packaging design and recommend improvements.
Qualifications: B.S. in E.E. or M.E. and experience or advanced knowledge in latest electronic packaging techniques.

RADAR ENGINEER to analyze ultimate limits of present techniques and develop new concepts of providing topographical sensors for advanced airborne and space systems; to design airborne radar pulse, microwave and deflection circuitry; to analyze doppler radar systems in order to determine theoretical accuracy and performance limitations.
Qualifications: B.S. or Advanced Degree in E.E. and 3 to 5 years' experience in radar systems development, including display equipment and circuits, control consoles, and doppler or search radar design.

CIRCUIT ENGINEER to undertake advanced circuit design based on transistor-diode logic for digital systems; to review new circuits for application in digital control systems; to define bas techniques for improving performance characte istics; to participate in advanced analytical stu ies associated with application of transist circuitry to pulse and digital systems.
Qualifications: B.S. or Advanced Degree in E.E and 2 years' experience with pulse circuitry transistor circuit design or digital techniques.

GROUND SUPPORT EQUIPMENT ENGINEER t assist in planning complete ground suppor equipment, including flight line, shop and depo equipment, for an advanced airborne weapon system. Must be experienced in development o test equipment for automatic checkout of com plex weapons systems, including computers radar, and inertial equipment.
Qualifications: B.S. or Advanced Degree in E.E or related fields and 3 years' experience in devel oping ground support equipment.

A wide variety of exciting career opportunities awaits creative engineers and scientists at IBM Owego in applying IBM's computer technology to integrated B-70 bombing-navigation systems. Test Equipment Engineer John W. Lloyd, describing his assignments at IBM Owego, says: "Test equipment engineering is particularly stimulating when it's part of a project as new and important as the B-70, sometimes described as a 'huge flying computer.' Right now I'm coordinating the design of engineering support equipment for an advanced digital airborne computer, part of the B-70's bombing-navigation and missile guidance system. There's a minimum of routine. In order to design test equipment you must know—or learn—about the equipment to be tested; among these are radar, servo systems, digital and analog computers, and inertial guidance. I see my professional growth assured as IBM continues to develop computers for airborne applications."

IBM is a recognized leader in the computer systems field. Its products are used for both military and commercial work. You will find ground-floor opportunities for professional advancement at IBM Owego, where the "small-team" approach assures quick recognition of individual merit. Company benefits set standards for industry today, and salaries are commensurate with your abilities and experience.

Ideally situated in rolling New York State countryside, Owego, in the Binghamton Triple City area, provides an excellent environment for gracious, relaxed family living. Owego's proximity to both New York City and the Finger Lakes offers a pleasant variety of recreational opportunities.

CAREER OPPORTUNITIES IN THESE AREAS . . .

- Airborne digital & analog computers
- Ground support equipment
- Inertial guidance & missile systems
- Information & network theory
- Magnetic engineering
- Maintainability engineering
- Optics
- Radar electronics & systems
- Servo-mechanism design & analysis
- Theoretical design & analysis
- Transistor circuits

There are other openings in related fields to broaden your skills and knowledge.

Qualifications: B.S., M.S. or Ph.D. in Electrical or Mechanical Engineering, Physics, Mathematics—and proven ability to assume a high degree of technical responsibility in your sphere of interest.

FOR DETAILS, just write, outlining background and interests, to:
Mr. P. E. Strohm, Dept. 685Z
International Business Machines Corp.
Owego, New York

IBM®
MILITARY PRODUCTS DIVISION

ever, there has been no evidence of malfunction of this vital part of the ground support system.

In addition to the two main pin-joint supports for the missile, there are two stabilizing arms in a plane 90 deg from the main supports. These arms provide support against overturning moment and have no part in the controlled rise-off. The two pin-joint supports and the two stabilizing arms provide the total four-point suspension system for the missile.

Launcher Must Resist 7000 F

The launcher must be heat-resistant. In a normal no-wind launch, the rocket exhausts are directed right down through the launcher, as can be seen from the picture on page 23. However, if launched in a wind, the missile will float horizontally for several feet before it is high enough to keep the rocket exhaust from impinging directly on the launcher and its components. Consequently, equipment and structure on the launcher must either be designed to resist the 7000 F rocket blast for several seconds, or be shielded from it. Both methods are used on the Atlas launcher. For example, some cabling is wrapped in asbestos, and other important parts are protected with metal shielding.

The launcher system must also be able to weigh the fully loaded missile. This is necessary in order to control the amount of propellants loaded, since the missile must have just the right amount on board at the time of launch to achieve maximum range. The weighing system, consisting of seven strain-gauge type weighing cells mounted between the launcher and its supporting structure, are designed to weigh the quarter-million pounds of liquid oxygen and RP-1 fuel to an accuracy of $^1/_2$ per cent. At the time propellants are loaded, the weighing cells are the only connections between the launcher and external structural support, since the trunnion pins which supported the missile-trailer-launcher during erection are removed prior to loading.

All ground connections to the missile are mounted on the launcher. Electrical umbilicals, pneumatic and hydraulic connections, propellant loading lines—all are automatically disconnected at launching.

Equipment described here has been used during the missile test program. It was conceived and designed at a time when the operational concept for the Atlas weapon system by SAC was somewhat nebulous. Yet much of this equipment will be used relatively unchanged in the early operational program.

Government contract awards

ARPA to Let R&D Contracts For High-Energy Solid Fuels

The Advanced Research Projects Agency has announced that it will release research contracts ranging from $1 to $2 million each to four chemical companies for long-range development of high-energy solid fuels to power military and space rockets. ARPA has a $20 million appropriation in fiscal 1958 for solid fuel research, of which these contracts would be only the first step in its multi-million dollar R&D program.

The four companies, screened from among 30 bidders, are American Cyanamid, Dow Chemical, Esso Research and Engineering, and Minnesota Mining & Mfg.

Packaged Powerplants

Thiokol's Reaction Motors Div. has received a prime contract from Navy BuAer for development of a larger and more powerful version of the prepackaged Guardian II liquid propellant engine.

GE Gets Development Jobs

General Electric has been awarded AF contracts for development of antimissile data vital to the U.S. over-all defense program, a plasma jet study, and a design study for construction of a laboratory hypervelocity projector. The company also received a design contract from Philadelphia Ordnance District for a two-stage mass gun for Aberdeen Proving Ground.

Kingfisher Award to Lockheed

A $2,786,953 award for additional flights of the Kingfisher target missile has been made by Army Ordnance to Lockheed Missile Systems Div.

Strato-Lab Study to Vitro

In an extension of its Strato-Lab research program, ONR has awarded a study contract to Vitro Labs for a manned stratosphere platform for scientific studies at 100-to-120,000 ft.

Pershing Contract to Martin

An $8,734,086 Army contract has been awarded to The Martin Co. for the Pershing missile weapons system.

NASA Awards

NASA has awarded Consolidated Electrodynamics a $67,000 contract for a high-vacuum chamber and pumping system to be used in space flight propulsion research at Lewis Research Center. CE will also supply instrumentation under a $447,600 contract for Lewis' new rocket systems research facility, now under construction.

Missile Telemetry System

Air Force has let a $1 million design and production contract to United Electrodynamics, A Division of United Geophysical Corp., for a transistorized telemetry system for Atlas, Titan and Thor.

$19 Million Job to Aerojet

The Navy has awarded Aerojet-General a $19.3 million contract for development and production of a new type long-range anti-submarine torpedo.

Missile Nose Cone Units

Republic Aviation has received a $464,000 follow-on order from General Electric for production and assembly of nose cone structural units for the Thor and Atlas missiles. Republic also received $16.1 million in AF follow-on orders for advanced models of the F-105 jet.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army and Navy contracting office:

AIR FORCE

AF Cambridge Research Center, ARDC, USAF, Laurence G. Hanscom Field, Bedford, Mass.

Study of intensity-time variations of cosmic radiation, $25,399, **Univ. of New Hampshire,** Durham, N.H.

Research on detection of infrared emission from satellite vehicles, $49,595, **MIT,** Cambridge, Mass.

Hq., AF Office of Scientific Research, ARDC, Washington 25, D.C.

Research on energy exchange in high intensity arc plasma, $66,111, **Vitro Labs,** 200 Pleasant Valley Way, W. Orange, N.J.

Continuation of research on solid propellant combustion, $49,862, **Atlantic Research Corp.,** Alexandria, Va.

Research on high speed gas dynamics, $201,099, **Princeton Univ.,** Princeton, N.J.

Research in trapping of free alkyl radicals, $56,602, **Atlantic Research Corp.,** 901 N. Columbus St., Alexandria, Va.

Continuation of research on program to scale up plasma jet thrust measurements, $115,000, **Plasmadyne Corp.,** 3839 S. Main St., Santa Ana, Calif.

ARMY

Boston Ordnance Dist., Army Base, Boston 10, Mass.

Feasibility study of fuels based on solids, $49,484, **Olin Mathieson Chemical Corp.,** New Haven, Conn.

Repair parts, Hawk missile, $497,933, **Raytheon Mfg. Co.,** Andover, Mass.

Flying DUKW Project, $25,000, **Avco Mfg. Corp.,** Stratford, Conn.

Procurement Office, Aberdeen Proving Ground, Md.

Recording equipment for ARPA satellite tracking complex, $67,638, **Ampex Corp.,** 8033 13th St., Silver Springs, Md.

San Francisco Ordnance Dist., 1515 Clay St., P.O. Box 1829, Oakland 12, Calif.

Missile borne television systems, Jupiter missile program, $58,317, **Lockheed Aircraft,** Missile Systems Div., Sunnyvale, Calif.

U.S. Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Computation facility operation, $1,681,591, **General Electric,** Computer Dept., 1103 N. Central Ave., Phoenix, Ariz.

Research and development contract, $79,105, **Douglas Aircraft,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Design and study, $49,964, **Aerojet-General Corp.,** 6352 Irwindale Ave., Azusa, Calif.

Feasibility study, $74,932, **Aerophysics Development Corp.,** P.O. Box 689, Santa Barbara, Calif.

Feasibility study, $61,010, **Radioplane,** 8000 Woodley Ave., Van Nuys, Calif.

Design and feasibility study, $52,241, **Nortronics,** 222 N. Prairie, Hawthorne, Calif.

Rocket engines, $50,000, **North American Aviation,** Rocketdyne Div., 6633 Canoga Avenue, Canoga Park, Calif.

Rocket motors, $1,080,000, **North American Aviation,** Rocketdyne Div., 6633 Canoga Ave., Canoga Park, Calif.

Engineering research and development regarding guided missiles, $2,476,271, **CalTech** 1201 E. California St., Pasadena, Calif.

Research and development for high precision orbit determination, $134,884, **Aeronutronic Systems, Inc.,** 1234 Air Way, Glendale, Calif.

Digital computer, $80,335, **North American Aviation,** 9150 E. Imperial Highway, Downey, Calif.

Feasibility study, $74,932, **Aerophysics Development Corp.,** Santa Barbara, Calif.

Research and development for construction of a device to produce nuclear environments, $142,117, **Hughes Aircraft,** Culver City, Calif.

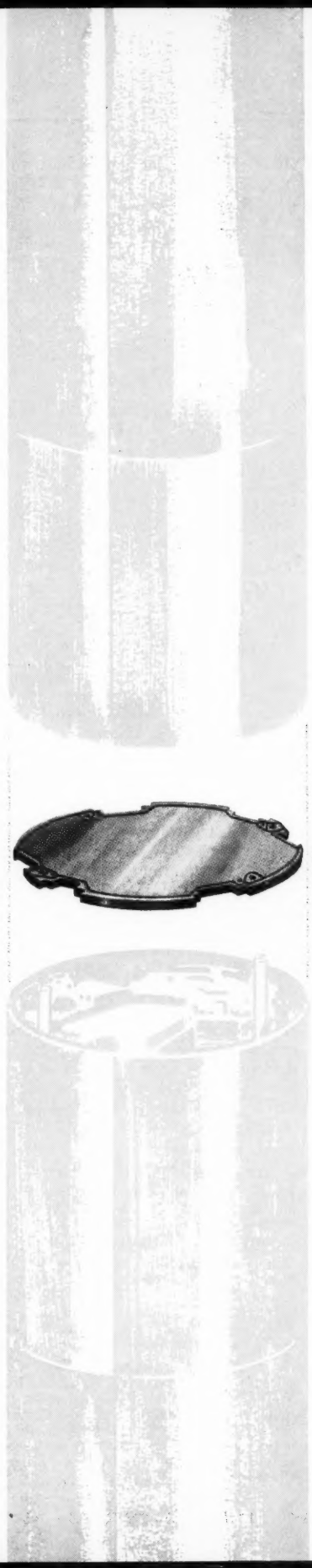
NAVY

Office of Naval Research, Washington, D.C.

Data handling system, $109,542, **Airborne Instruments Lab,** Mineola, N.Y.

Services involving operation of Minitrack satellite tracking system sites, $335,680, **Bendix Radio,** Baltimore, Md.

Study in the fundamental aspects of data retrieval, $40,000, **Benson-Lehner Corp.,** Los Angeles, Calif.



Do you know about Gask-O-Seals?

THIS Gask-O-Seal

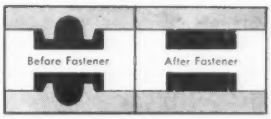
EXCEEDS HERMETIC SPECS!

Gask-O-Seals often equal or exceed *specification for hermetic* sealing. The one shown here, for instance, has eight sealing points and is on one of our newest missiles. The leakage rate is less than the original *hermetic* seal specification called for which is about as perfect as any seal can be.

Gask-O-Seals are high and low pressure static seals which require NO groove machining to accommodate. A flat surface with only a 125 RMS surface finish is all you have to provide to get positive sealing with a Gask-O-Seal.

There are many other outstanding features about Gask-O-Seals: Limited area for fluid attack, no loss of structural strength, rigid, easy to install and replace, no tolerance build-up possible in seal cavity, etc.

Why not find out about Gask-O-Seals and the other seals of Parker Seal Company's "O-Seal Family"—by the makers of Parker O-rings.



Parker
SEAL COMPANY
CULVER CITY, CALIF. • CLEVELAND, 12, OHIO
A DIVISION OF Parker Hannifin CORPORATION
(Formerly F. C. Wolfe Co. & Rubber Products Div. of Parker Appliance Co.)

ASI ENGINEERS & SCIENTISTS

Here is your opportunity to grow with a young, expanding subsidiary of the Ford Motor Company. Outstanding career opportunities are open in Aeronutronic's new RESEARCH CENTER, overlooking the Pacific at Newport Beach, and the facility in Glendale, California. You will have all the advantages of a stimulating mental environment, working with advanced equipment in a new facility, located where you can enjoy California living at its finest.

PhD and MS RESEARCH SPECIALISTS with 5 to 7 years' experience in heat transfer, fluid mechanics, thermodynamics, combustion and chemical kinetics, and thermoelasticity. To work on theoretical and experimental programs related to re-entry technology and advanced rocket propulsion. Specific assignments are open in re-entry body design, high temperature materials studies, boundary layer heat transfer with chemical reaction, thermal stress analysis, and high temperature thermodynamics.

PROPULSION ENGINEERS with 5 years' experience in liquid and solid rocket design and test. Familiarity with heat transfer problems in engines desirable. To work on program of wide scope in R & D of advanced concepts in rocket engine components, and for missile project work.

ADVANCED AERODYNAMIC FACILITY DESIGNER. Advanced degree desired. To supervise work in design and in instrumentation of advanced aerodynamic test facilities such as shock tubes, shock tunnels, plasma-jets, and hyper-velocity guns.

STRUCTURAL ANALYSIS SECTION SUPERVISOR with 8 to 10 years' experience, including supervision, in the missile field. Graduate degree for design and analysis required. Will be required to apply knowledge of high temperature materials and methods, thermal stress, dynamics, etc. to advanced hypersonic vehicles, re-entry bodies, and space vehicles.

FLIGHT TEST & INSTRUMENTATION ENGINEERS with 5 to 10 years' experience in laboratory and flight test instrumentation techniques. Will develop techniques utilizing advanced instrumentation associated with space vehicles.

THEORETICAL AERODYNAMICIST. Advanced degree and at least 5 years' experience in high-speed aerodynamics. Knowledge of viscid and inviscid gas flows required. To work on program leading to advanced missile configurations. Work involves analysis of the re-entry of hypersonic missiles and space craft for determining optimum configuration.

DYNAMICIST. Advanced degree, applied mathematics background, and experience in missile stability analysis desirable. Work involves re-entry dynamics of advanced vehicles and dynamic analysis of space craft.

ENGINEER or PHYSICIST. With experience in the use of scientific instruments for making physical measurement. Work related to flight test and facility instrumentation. Advanced degree desired with minimum of 3 years of related experience.

Qualified applicants are invited to send resumes and inquiries to Mr. L. R. Stapel.

AERONUTRONIC SYSTEMS, INC.

A subsidiary of Ford Motor Company

1234 Air Way, Bldg. 20, Glendale, Calif.
CHapman 5-6651

In print

Artificial Satellites, by A. Shternfeld, translated from the Russian "Iskusstvennye Sputniki" by Technical Documents Liaison Office, Wright-Patterson AFB, Ohio, available from Office of Technical Services, U.S. Dept. of Commerce, Wash. 25, D.C., 424 pp., illus. $6.

Anyone with an interest in Soviet rocketry and astronautics would do well to avail himself of the opportunity to read this volume. One of the most popular Russian works on the subject, it was originally written in 1956 and won for its author the Soviet international prize for the promotion of astronautics. The present translation is based on a second revised and extended edition of the earlier volume, published by the State Publishing House of Technical and Theoretical Literature in Moscow earlier this year.

While the book provides no answers to the question of what type of vehicles the Russians have been using to launch their satellites, it does offer some clues as to future Soviet space flight plans. The table of contents alone seems to read like a Soviet pattern for astronautical activity, proceeding from a theoretical examination of satellites (laws of motion, motion of the satellite relative to an observer on earth, etc.); through construction and launching (including an examination of the rocket engine), satellite observation, man in space, and re-entry and recovery; to a consideration of the establishment of artificial satellites of the moon, the planets and the sun, and of the use of satellites both as flying observatories and laboratories and as interplanetary stations.

There is surprisingly little boastfulness about Soviet achievements or propaganda in the book. Rather, it seems to be a successful attempt to acquaint the well-read Russian man-on-the-street with the subject of satellites and their implications.

As such, it does not represent a major contribution to the scientific literature. However, it should not be regarded merely as another "popular" book on the subject. While largely a theoretical analysis, it does provide some inkling as to Soviet thinking, and the average reader will find it an excellent semitechnical introduction to the entire subject, far more complete than many similar efforts published both here and abroad.

OTS is to be congratulated for making the translation available. However, the offset printing process used has made the photographs in the original volume all but unrecognizable, although charts and figures have to a large extent been redrawn and are perfectly clear.

It is to be hoped that publication of "Artificial Satellites" is only the first step toward a full-scale effort by OTS and other government agencies to make available major Soviet contributions to the technical literature.

—I.H.

BOOK NOTES

Plasma in a Magnetic Field, edited by Rolf K. M. Landshoff (130 pp., Stanford Univ. Press, Stanford, Calif., $4.50), presents 10 papers from a symposium sponsored by Lockheed Missile Systems Div. in late 1957. Two papers on kinetics contrast individual orbit analysis and a modified macroscopic theory of the motion of charged particles in a magnetic field; four explore instability at the interface of plasma and field; and four describe how high-speed plasma can be both generated and modified by magnetic forces.

Aircraft and Missile Propulsion, Vol. II, by M. J. Zucrow (636 pp., John Wiley & Sons, New York, $13), the second in a three-volume text for the engineering student on the principles and technology of jet propulsion and rocketry, discusses the working characteristics of gas turbine, turboprop, turbojet, ramjet, and rocket (solid and liquid propellant) engines. The author's person speaks for the quality of technical discussion in this book. It has, moreover, the advantages of detailed explanation of derivations, illustrative problems, summary tables and figures needed to solve problems, clear notation, references, and numerous problems for the student. The section on rocket propulsion hues tersely to fundamentals, yet it points out gaps in theoretical understanding.

RECEIVED

Rocket Refractories, by H. B. Porter (55 pp.; order from OTS, Dept. of Commerce, Wash. 25, D.C.; $1.50). Review of high-temperature refractories up to 1955.

Industrial Carbon and Graphite, by the Society of Chemical Industry, London (630 pp., Macmillan, New York, $25.75). Some 60 papers presented at London in Sept. 1957, covering physical properties and manufacturing methods.

The Structure of Glass (298 pp., Consultants Bureau, Inc., 227 W. 17 St., New York 11, N.Y., $20). Published under the joint sponsorship of the American Ceramic Society and NSF, this book presents 75 translated papers from a 1953 conference convened by the Institute of Silicate Chemistry, U.S.S.R.

infrared ROVERS . . .

fast-maturing TI infrared systems advance IR early warning, reconnaissance, tail-warning...

ALL-OUT DEVELOPMENT of the precocious infrared sciences at Texas Instruments has brought this versatile field to new levels of sophistication — a maturity that spells design simplicity in complex systems, and permits expert use by inexperienced personnel. The keys to this new status for infrared are *new optical materials, new materials/systems/application matching techniques, advanced detector cells,* and *low-noise transistorized circuitry* — all pioneered by Texas Instruments.

This experience can work for you immediately, whether your particular interest is reconnaissance, distant detection, early warning, tracking, tail-warning, or merely curbing a heat-seeking missile's tendency to chase the sun. To obtain IR technical services, backed up by the capacity to produce in any quantity the systems you require, properly cleared military or industrial personnel contact SERVICE ENGINEERING DEPARTMENT:

apparatus division

systems management

systems — airborne early warning, airways control, antisubmarine warfare, attack-bomb navigation systems, countermeasures, engine instrumentation, missile systems, portable ground equipment, reconnaissance, space electronics.

equipments — radar, infrared, sonar, magnetic detection, computers, timers, telemetering, intercom, microwave, optics, detector cells, engine instruments, transformers, time standards, and other precision devices.

research design development manufacture

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

Your Space-Age OPPORTUNITIES with DYNA-SOAR

Bell Aircraft Corporation, a member of the Martin-Bell industry team developing the Dyna-soar hypersonic glider for the U. S. Air Force, offers high-level openings on this challenging project. These positions will appeal particularly to experienced engineers who desire an opportunity for rewarding progress in advanced research, analysis, design and development of space vehicles affording full scope to their creative ingenuity with unusual opportunities for rapid advancement and professional recognition.

NAVIGATION SYSTEMS SPECIALIST to investigate and establish requirements for inertial, radar radio and air data sensing systems with responsibility for setting up and planning tests as required to verify theories. BSEE or BSME with 6 years' experience in related fields required.

FLIGHT CONTROL SYSTEMS SPECIALIST to determine need for the most suitable methods of obtaining automatic and manual flight control, stability augmentation, power boost pilot displays and controls. BSEE or BSME with 8 years' experience in related fields.

AERODYNAMIC HEAT TRANSFER GROUP LEADER to direct and lead heat transfer group in performing analysis of aerodynamic heating of aircraft through complete speed range from subsonic to hypersonic, and to develop and apply new methods for performing these analyses. PhD or MS in Aero, Physics or Applied Math with 3–5 years' experience.

GASDYNAMICS SPECIALIST to initiate and perform fundamental and applied theoretical research in fields of gasdynamics particularly at hypersonic speeds, and to initiate, perform and/or monitor basic applied experimental research on fundamental hypersonic flow and physical phenomena. PhD or MS in Aero Engineering, Physics or Applied Math with 3 years' experience.

Salaries are commensurate with your background. Good living and working conditions prevail with liberal benefits. Write:

Supervisor, Engineering Employment,
Dept. Y-63

BELL AIRCRAFT CORPORATION

BUFFALO 5, NEW YORK

X-15: Mach 7 Aircraft

(CONTINUED FROM PAGE 47)

units presented a problem because of the temperature ranges expected. Hydrogen peroxide, a catalyst and a turbine were selected for use in the unit, but it took a good deal of time and effort to find reliable fluorinated plastic compounds for the flexible bladders within the pressure vessels needed for the hydrogen peroxide. And the vessels themselves required extremely strong construction because of the tremendous pressures—in some cases up to 4000 psi—of the gases and fluids they contain.

In addition, a new hydraulic fluid that would flow in heat and cold had to be found; O-rings to hold fluids and gases at high pressures and temperatures had to be developed and tested; and a process that insured the absolute cleanliness of vessels and lines involved the testing of hundreds of combinations of cleaning mixtures.

Eight Major Subsystems

The X-15 is actually made up of eight major subsystems—the rocket engine, propellant system, hydraulic system, primary flight controls, auxiliary power units, ballistic control rockets, landing gear, and the air conditioning and pressurization system.

The engine is the 50,000-lb thrust RMI XLR-99. However, two four-barreled RMI XLR-11-5 powerplants —the same as that used in the Bell X-1—will be used in the X-15's initial flight tests, giving the advantage of tried and proved engines for this part of the program.

Propellants for the XLR-99 engine are lox and liquid ammonia, fed by a pressure system providing a flow in excess of 10,000 lb per min. (For comparison, the rate of fuel flow in a modern jet fighter with afterburner, such as the F-100, is from 30,000 to 40,000 lb per hr, which means the X-15 will consume propellants approximately 20 times as fast.) Decomposed hydrogen peroxide provides a high-temperature gas used to drive a turbine-propelled pump to boost the lox and ammonia to engine manifold pressure. Helium gas is used for tank pressurization and liquid expulsion.

The hydraulic system, powering horizontal and vertical tail control surfaces, speed brakes, and landing flaps, consists of two complete and separate 3000-psi systems operating in parallel. The hydraulic system is driven by a new "piggy-back" combination of pumps. The total weight of the system is less than that used in the F-100C Super Sabre.

Primary flight controls, a further development and extension of the conventional method, are designed to accommodate increased surface loads, high g forces and high operating temperatures. The stability-augmented controls are powered by North American-developed hydraulic actuators specially designed to meet high-temperatures requirement.

On reaching extreme altitudes, where there is not enough air in the thin atmosphere for normal controls to work, the X-15's controllability will be dependent upon hydrogen peroxide thrust units (control rockets), located in the nose and wingtips. These work by moving the airplane opposite to the force of the jet streams of the gas. Pitch and yaw is controlled by the nose jets, roll in the wingtips. Actuated from a specially designed three-axis control in the pilot's compartment, they will enable him to maintain the proper flight attitude during the ship's trajectory through the thin air.

The X-15 is equipped with two auxiliary power units, which operate in parallel to supply electrical and hydraulic power. Hydrogen peroxide is used for their fuel. Use of the two units insures reliability of electrical and hydraulic systems.

The ship's landing gear departs from the conventional by the use of two steel skids located on the aft section below the horizontal stabilizers. Dual nose wheels are also utilized to give directional stability during high-speed land. Both landing skids and nose wheels are manually retractable into the fuselage for flight, and are extended mechanically by means of gravity and the air stream.

Liquid nitrogen is utilized for the air conditioning and pressurization system. Featuring a unique design and use of newly developed insulating materials, the pilot and delicate instruments contained in the X-15 are protected against the extreme temperatures anticipated by the system, which weighs only 150 lb but has a cooling capacity of 27,000 Btu.

Rollout of the X-15 was actually two weeks ahead of a schedule set three years ago. Flight tests will get under way in February at Edwards AFB, with NAA chief test pilot Scott Crossfield at the controls. These NAA tests are designed to demonstrate the ship's structural integrity and propulsion and control system performance, and will be carried out within known flight envelopes.

Upon completion of the tests to the Air Force's satisfaction, the X-15 will be turned over to the flight test steering committee for the research program. Primary responsibility for this program will rest with NASA, which will coordinate efforts with the Air Force. NASA test pilot Joseph Walker

will fly the ship for NASA, AF Capt. Robert White for the Air Force.

A typical X-15 mission (see page 46) will begin with an air-drop from a B-52 at as high an altitude as can be achieved. Total time of flight will be about 20 min and burning time during powered flight about 90 sec. The flight will be tracked by means of a radar range running from Edwards AFB to Wendover, Utah, some 400 miles.

The ship will, of course, undergo very high acceleration during powered flight. Since aerodynamic controls will be ineffective in flight outside the atmosphere, the reaction-type controls will be used during such periods. The pilot will be weightless during a large portion of the period between burnout and re-entry.

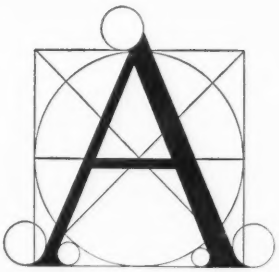
The X-15 has three control sticks—a center stick, as in conventional aircraft, as well as right- and left-hand sticks. The right-hand stick will be employed when the pilot is under a high-load factor and in the atmosphere during boost and re-entry, with the left-hand stick used outside the atmosphere. The conventional stick can be used after re-entry if the pilot so desires.

The instrumentation bay is directly behind the cockpit. Instruments were designed and supplied by NASA. An inertial platform is also included in the bay. Auxiliary power units are located adjacent to this bay. The area aft of this compartment is filled with lox, ammonia and helium pressure tanks.

Large side fairings on the ship's fuselage house propellant and control lines. Unusual vertical tails, both above and below the fuselage, are wedge-shaped. This shape was selected on the basis of wind tunnel tests for maximum directional stability with low weight. Movable upper and lower vertical surfaces provide directional control. The bottom part of the vertical tail will be jettisoned prior to touchdown to prevent ground interference on landing. The aft portion of both the upper and lower tails will be used as dive brakes.

Aviation "Man of the Year"

Maj. Gen. Bernard A. Schriever, Commander, AF Ballistic Missile Div., has been named aviation's "Man of the Year" and awarded the AF Assn. Gen. H. H. Arnold Trophy. H. Julian Allen, chief of the High-Speed Research Div. of the NASA Ames Research Center, has been awarded the AFA 1958 Science Trophy, while the late Capt. Iven C. Kincheloe Jr. was awarded the David G. Schilling Memorial Trophy posthumously.



ppointments at the highest echelons to holders of advanced degrees in physics, mathematics, electrical and mechanical engineering

Litton Industries offers research appointments of the highest order of importance to the nation's defense and economic endeavors. Applicants must have proven capability at the professional level for contributions toward the advancement of knowledge in the fields of computation, guidance, communication, or control.

In the field of Space Research, appointments will be made within the disciplines of astronautics, bioastrophysics, basic physics, and hyperenvironmental testing.

These few men will have as their resources the skills of any of a thousand people who are the life of the electronic complex which is the Electronic Equipments Division of Litton Industries. They will command the most advanced computational instruments as their tools, plus the only Inhabited Space Chamber in the free world, plus engineering and manufacturing facilities which produce complete systems.

The locale is Southern California where both the physical and intellectual climates are to be enjoyed. Send a brief resume to G. I. Dawson, Litton Industries, Electronic Equipments Division, 9261 West 3rd Street, Beverly Hills, California.

LITTON INDUSTRIES
Electronic Equipments Division

ICBM Launch Control

(CONTINUED FROM PAGE 25)

operates plays a major role in reducing countdown time from the tedious hours or days required at missile test centers to the minutes required by tactical considerations.

APCHE has uses other than determining operational readiness of missiles on the launch pad. Similar equipment is used for missile assembly and maintenance in the squadron maintenance area, some miles back from the launch area. Another use is for component testing during missile manufacturing.

Heart of Launching Operation

The heart of the launching operation is the Launch Control Center in the blockhouse. The blockhouse is equidistant and over 1000 ft away from the launch pads for which it is the control point. On the front wall of this room are mounted standby-status panels and TV viewers. Standby-status panels indicate, through translucent placards illuminated by appropriate colors, the degree of missile readiness. Degree of missile readiness can vary from "no missile on pad" through "X hours maintenance required" to "missile ready."

TV viewers, connected to selectable remotely controlled cameras, permit observation of the missile throughout the entire countdown, including firing.

Control consoles are arranged in three rows. One row contains a complex facilities console, used by the facilities operator to operate TV cameras, monitor fire extinguishing systems, main power sources, etc. One such console will serve an entire blockhouse, regardless of the number of launch pads operable from the one blockhouse.

The launch operator's and analyst's consoles make a second row. These are two-panel consoles, requiring two operators, with one console per launch pad.

The launch operator uses pushbuttons to start each missile system in proper sequence. Colored lights on the console panel tell him whether a particular sequence is in progress, has been completed, or has failed. The launch analyst's panel consists of an animated diagram of major systems, plus indicator lights. When a hold is indicated on the operator's console due to a system failure, the analyst's job is to diagnose the trouble that resulted in the hold. Based on his diagnosis, it may be decided either to abort the launch, hold for repairs, or proceed on a calculated-risk basis.

This decision, however, is the responsibility of the launch control officer, seated at the rearmost console of the launch pad group. From here, the launch control officer monitors the operation of the launch pad for which he is responsible. The launch control officer also selects the target in accordance with instructions from his superiors, and initiates the final "missile commit" sequence, which results in the actual launch. A digitally controlled countdown clock, located on the launch control officer's panel, indicates time-to-go for missile launch and automatically resets itself forward or back, depending on progress of the launch sequence.

In the design of the panels and control systems, a fine balance had to be struck between the advantages of complete automation, with its concomitant inflexibility and complication, and the advantages of using human judgment, with its ever-present possibility of disastrous error. Since the definition of "fine balance" is not a numerical one, it is subject to personal opinion. Consequently, there are two entirely divergent schools of thought, each holding to opposite notions of what constitutes a proper approach.

Override vs. Anti-Override

For example, some operational crews are inclined to mistrust too many automatic holds that do not have permissible overrides. This mistrust stems partly from a deep-seated belief, based on experience, in the judgment capacity of a well-trained man. This school believes in override controls that permit exercise of human judgment, something that machines are inherently incapable of. For example, one possible reason for a countdown hold might be inability to fuel the missile to full capacity. The override protagonist would prefer to use his partially fueled missile on a less distant "target of opportunity," as he puts it, rather than have it destroyed on the pad by enemy action.

The anti-override spokesman, on the other hand, argues that, with Armageddon about to break out over the heads of a missile crew, one could expect even the best trained man to exhibit some signs of haste. And the "target of opportunity" might then prove to be some innocent hamlet.

The design of launch control equipment is a human engineer's dream. Operator reliability is so vitally important that the human engineer, who has made a science of common sense, is given free rein in specifying error-proof switches, indicators and panel layouts. Considering the consequences of error in a tactical mission and the cost of missiles, the cost of such panels is a negligible item.

For example, all switches are of the pushbutton or "panic" type. No toggle switches, with their possibility of incorrect operation, are used. Colors are used liberally, but not excessively, to indicate system operational status. Colors are chosen to permit toleration of mild degrees of color blindness in operators. The height of letters is determined by the necessity for visibility under conditions of stress and fatigue, regardless of the fact that panels thereby grow larger and more costly.

Husky Relays Used

Reliability of equipment is uppermost in the design engineer's mind. The only vacuum tubes in the Atlas launch control system are in the TV system, which is not vital to the missile's operation. Relays are extensively used and are chosen to stand up, not to look good. Since neither weight nor size is of importance, none of the glamorous miniature relays with their microscopic clearances, wire sizes and life (relatively speaking) are used. Most of the relays are great husky brutes that are just feeling broken-in after a million operations. In a peaceful age to come, some archaeologist, poking about the desolate landscape of an ancient Atlas base, will surely sift a few good relays out of the dust.

During the design phase, a healthy air of skepticism accompanies the perusal of component manufacturers' specifications. Everything is checked —especially transistors. Big Brother watches the circuit designer, too. An independent group critically reviews every circuit with regard to itself, its application to the system, and the rating and limitations of its components.

It all seems lavish at first. But it is necessary—and a taxpayer's bargain, at the present price of missiles. And this striving for perfection may make our first spaceman feel just a little less tense as he sits, high above the launch pad, waiting for the start of that first crushing push.

Project Eclipse Unmasks the Sun

The five Nike-Asp rockets launched near Danger Island in the South Pacific during the Oct. 12 solar eclipse established that X radiation emanates from the sun's corona and that ultraviolet originates in the chronosphere, near the sun's disk. These findings, reported by Herbert Friedman of NRL, confirm theory and will aid in interpreting the nature of the earth's ionosphere.

Polaris Launching System

(CONTINUED FROM PAGE 41)

criteria apply to fixed sites, particularly hard sites, where confined spaces and high costs put a premium on optimum launching and handling.

Having developed the criteria against which a launching concept must be weighed, a selection must be made from the basic types of launching techniques. These might be categorized as:

1. *Static launching*, or any technique where the missile takes off under its own power, as from a stool or short rails from an open position.

2. *Dynamic launching*, or any technique where the missile is catapulted or boosted off with later main-stage ignition, from an open or enclosed position.

3. *Combination of static and dynamic launching*, or any technique in which the missile is catapulted or flown from an enclosed position with main-stage energy.

We can skip over the laborious and time-consuming procedure involving engineering studies of a preliminary nature necessary to weigh thoroughly the advantages and disadvantages of each launching method. The problem was reduced ultimately to studies of submarine application, since the operational criteria showed this to be by far the most attractive ship type. The combined method could be eliminated early. The simplicity is obvious in a scheme in which the missile was ignited in a tube of proper diameter to either fly out or be expelled by pressure of exhaust gas.

However, each major step in solid propellant development in the past has suffered setbacks in some degree from explosions, or case blowouts, until sufficient experience and development could accrue. Such an occurrence in a ship or hard site is tantamount to loss—an unacceptable risk. Further, if exhaust gases are discharged about an annular clearance between missile and tube, the missile sees a nasty environment, including heat, blast pressure, and white noise of frightful intensity, not to mention the fact that the aerodynamics are completely reversed, since the missile is flying backward relative to the surrounding gas stream.

We devoted considerable time and effort to a study of static methods with all combinations of storage and handling. Submerged launching from the deck was completely impracticable without undue complexity. Machinery design necessary to raise the missiles to an elevated position was of monstrous proportions and even then

high-energy fuel briefs from Callery

New HiCal plant dedicated at Muskogee, Oklahoma — The nation's first large-scale high-energy fuel plant was dedicated on November 1 by the Navy at Muskogee, Oklahoma. Callery built and will operate the $38-million plant for the Navy. When tonnage quantities of HiCal are produced at the plant next year, the high-energy liquid fuel will be used extensively in tests on various types of propulsion systems such as turbojets and ramjets. *Write for new Technical Bulletin, C-1110: HiCal-3 Compatability with Materials of Construction.*

Dayton, Ohio office opened by Callery — Fuel and propellant users in the Dayton area can now utilize Callery's newly opened office to obtain technical service on their growing needs in aircraft fuels and propellants: 2600 Far Hills Avenue, Room 12, Dayton 19, Ohio; telephone AXminister 3-2752.

New ignition-delay data on Triethylborane — Just published data (C. J. Marsel and L. Kramer, Supplementary Preprint of Papers, Seventh International Symposium on Combustion, 655-61, Sept. 3, 1958) on Triethylborane (TEB) ignition delays: 20 msec. at 5 in. Hg, 50 msec. at 2 in. Hg, and 40 msec. at 0.5 in Hg, with inlet air at 450°F. For JP-5-TEB mixtures at 450°F and 5 in. Hg, the delay is 170 msec. with 51.8% TEB and 200 msec. with 39.8% TEB; spontaneous ignition does not occur with 38.5% TEB.

TEB can be used as a pyrophoric ramjet fuel, as a reigniter for turbojets, and as an additive to improve combustion properties of JP and RP fuels. *Write for Technical Bulletin C-310 and Handling Bulletin C-311.*

R & D Lab employees earn another safety award — Employees of Callery's Research and Development Laboratories have earned two safety awards in the past year. Most recent achievement: 571,571 man-hours without a lost-time accident.

In the first six months of 1958, Callery's R & D employees have had one-third the number of accidents — and one-fiftieth the number of days lost from accidents — as the average of comparable chemical plants. *HiCal-3 Handling Bulletin C-1100 is available on request.*

Phone: FOrest 4-1130
TWX: Perrysville, Pa. 117

Anthony C. Hummel
Technical Representative
Defense Products Department
Callery Chemical Company

CALLERY
CHEMICAL COMPANY
9600 PERRY HIGHWAY
PITTSBURGH 37, PENNSYLVANIA

could not practicably maintain the desired rate of fire nor meet underwater criteria. Magazine handling machinery ate up the space available. Finally, the exposed missile on deck was unsuitable for extreme weather environments.

It may be said generally that handling schemes for missiles requiring many auxiliary services such as umbilicals, the usual environmental controls, and fueling, in the case of liquid missiles, became complicated and messy. Gyro gimbals restrict the degree of freedom of movement, and structural fragility means exceptional care, with cradling against distortion, vibration, and shock.

Tube Solves Many Problems

Since handling methods and restricted space in submarines tend to be antithetical, consideration of dynamic launch techniques could be restricted to combining the launcher and storage magazine. If the magazine was a tube, the problem of guiding the catapulted missile could be effectively solved. The tube could be closed to sea while submerged, and hatches from the interior of the submarine into the tube could provide access for servicing. Minimum space, or maximum packing, could be achieved by nesting the tubes, and the weight was less than that of a handling system. Maximum rates of fire could be achieved since countdown sequences could be performed in parallel. Heat, blast, noise, and safety problems could be solved at a stroke by ignition after launch through use of a simple timer or pullout lanyard. In review, it appeared that all our criteria could be satisfied in the optimum manner by means of a catapulting technique.

Perhaps it might be well to note that the actual process of launch system selection was not quite so logically and clearly pursued as the above implies. Looking back, it is easy to rationalize and Sunday quarterback the plays.

In actuality, our major effort in static launching engineering was accomplished by Chrysler Corp. and Westinghouse Electric Corp. with a liquid-fueled missile and surface-ship application as early test objectives. Although catapulting systems were also designed, the effort was secondary, since delayed ignition with liquid engines appeared a formidable reliability problem. Further, even though great strides were made in evolving rapid fueling and servicing techniques, missile preparation and rate of fire were unacceptably long. For these and other compelling reasons, the solid propellant effort came to the forefront.

Lockheed Missile Systems Div. studied and recommended ejection from a tube, since the proposed missile design could accept direct application of a propellant gas, as against using a carriage or shuttle familiar in aircraft launching. When the solid propellant Polaris was approved for submarine application, Westinghouse closed the files on the static launch effort and commenced design and development of an ejection unit. Naval Air Engineering Facility catapult studies for liquid rockets were then reoriented to Polaris, and a team with Westinghouse formed.

They took off with remarkable speed and were successfully testing full-scale within two months of the launch system decision in Special Projects. In another eight months, they were successfully testing submerged launches in operation Pop-Up. Here, a much larger and truly outstanding effort was necessary, with Lockheed providing test vehicles, Mare Island Naval Shipyard a submersible vessel to carry the launcher, Long Beach Naval Shipyard supporting the operation, and the whole operating under the test management and direction of the Naval Ordnance Test Station, Pasadena.

Lest we suggest that all our troubles are solved, let's take a look at some of the problems we mentioned earlier. The energy source offers many interesting problems. Gases such as air, nitrogen, or steam may be stored in an accumulator and triggered to the chamber below the missile to expel it. This method requires a poppet valve design and valve control system of sufficient flexibility to accommodate a range of launching conditions which are usually defined in terms of missile weight, end speed, and limiting acceleration.

In design of the launcher tube, the obvious problems are those associated with power stroke length, and guiding and supporting the missile. However, we noted earlier that auxiliary equipment and service details wag the dog. Tube mounting for shock and vibration, provision of access, umbilical connections, ventilation, pressurizing, flooding, and draining all require a major effort. These are the details through which compatibility between missile and ship are achieved. The compatibility problem is further complicated by the fact that the missile, ship, and launcher are concurrent designs, making changes to keep in step the rule, rather than the exception.

In the design of tube and power source, reliability and safety are the major factors. Energy sufficient to expel the missile into the air must not be inadvertently released in the submarine, and precautions against fire must obviously be engineered into a system which is essentially a magazine. Certainty of launch under the conditions specified imposes the need for reliability engineering from concept through product evaluation. Since our development designs are subject to frequent change, the reliability program must be highly tuned to respond to an off beat.

We can end this discussion by noting our greatest problem, that of submerged launch. The Polaris launch system is unique today in its surface application. Although launching from tubes is as old as rockets, the further condition of submergence adds a new dimension to the problem, and it has never before been attempted on this scale.

A new set of parameters, hydrodynamic in nature, and completely foreign to normal missile environment, is introduced. We must design our launcher to propel the missile a point above the surface without imposing angles of attack too great for the structure in bending, without pressures which could cause collapse, and without large flight deflections. The missile must broach rapidly to avoid prolonged exposure to surface waves. Thus the characteristics of sea state, resulting effects at depth, ship motion, and missile hydrodynamics must be determined and applied.

We have scratched the surfaces with enough successful launches to be confident of this new Navy capability of such great national strategic import. However, we need much more scratching to understand our limitations.

Largest Privately Owned Metallurgical Lab Opened

Nuclear Metals, Inc., formally opened the free world's largest privately owned metallurgical laboratory in Concord, Mass., Oct. 24. The company is an outgrowth of the Metallurgical Project of MIT, which got under way in 1942, and took its present name in 1954, when Arthur D. Little and Allegheny Ludlum Steel Corp. were selected by the AEC to continue the activities of the project.

At the opening of the $2 million research center, Albert R. Kaufman, vice-president and technical director of the company, revealed that NMI is now doing research work aimed at improving the ductility of beryllium under an AF contract, and commented that the metal may some day find use as a structural material in missiles and space vehicles.

AF Logistics

(CONTINUED FROM PAGE 31)

mass and complexity of the equipment needed to substitute for that superb, although highly vulnerable, human mechanism.

The mass and complexity of ground support and checkout equipment is truly staggering. It will cost, on the average, twice as much as the missile inventory itself, and we anticipate that it will be responsible for at least 80 per cent of the maintenance load generated by the total system.

The size of the maintenance load, however, is only part of the problem. Maintenance and the spares support behind it must be adequate and timely to a degree never approached before. Unlike the manned system, the missile can tolerate malfunction in *none* of its parts. The crew of a manned bomber can compensate for a considerable amount of error or failure within its various components and subsystems.

Fast Response Poses Big Demands

The second problem in ballistic missile logistics is introduced by the operational requirement of a reaction time measured in minutes, rather than hours. While this is in part a characteristic of the missile, the requirement of quick response is in reality more a consequence of modern warfare itself. We face this same requirement in manned aircraft. It places tremendous demands on logistics. In the Strategic Air Command, this problem is partially solved by maintaining a portion of the force airborne at all times, obviously not a practical approach to the ballistic missile.

When this fast reaction requirement is combined with those arising from the pilotless nature of the missile, a truly formidable logistics problem is created. It generates at the launch site a constant requirement for exercise and checkout, for replacement of parts, and for maintenance.

I should like to emphasize that this rapid response characteristic presents primarily a logistics problem. Weapons of this type are not "fought" in the classic sense. The strategy and tactics are pretty well cast in concrete. They are only maintained and then launched toward pre-established targets.

The third problem confronting the missile logistician is self-imposed, and arises from our efforts to compress the time span between research and development and an operational capability in the field. In attempting to do this we have abandoned the classic "Fly Before You Buy" philosophy. We are committing to production hardware which will need to be supported from the standpoint of supply and maintenance in the field long before the R&D program has been finished, and without the benefit of an operational suitability testing period in which to shake down basic design under field conditions.

R&D hardware in the field in quantities puts the logistics man between a rock and a hard spot. On the one hand, he knows constant engineering changes dictated by results of the test program will make obsolete at a very high rate his stocks of spare parts and his maintenance facilities. On the other hand, since there has been no service testing, he has no data on which to compute consumption and failure rates. Thus he is not in a position to calculate with any degree of accuracy what stock levels of spare parts should be maintained and what maintenance capability is required in the field or at depots or contractor plants. To the extent he errs on the low side, there is a resultant reduction in operational capability. If he errs on the high side, the cost of the components involved could result in a serious impact on our ability to procure missiles and ground support equipment initially.

It appears, then, that these peculiarities of the ballistic missile system are complementary in generating one large problem. The fact that it is unmanned, that rapid response is required, and that it is R&D hardware expected to perform an operational mission, make this system extremely sensitive to supply and maintenance support adequacy.

Yet the size and complexity of the total system itself—that is, flying hardware as well as ground support equipment—demand that waste in terms of obsolescense of spare parts and maintenance capability be held to minimum in order that dollars can be used for initial procurement.

"Single Manager" A Possibility

From an analysis of possible ways in which we might reduce the impact of this problem to a minimum, it became apparent that a departure from the Air Force's existing management structure in the logistic support field would pay dividends. Rather than continuing to rely on a number of depots, each providing supply and maintenance support for certain prime classes of equipment, a "single manager" for procurement, distribution and maintenance of all assets in support of ballistic missiles was indicated.

Through centralized knowledge and control of all assets, maximum efficiency in their utilization could be

Written and directed by Willy Ley (author of the book of the same title). Recorded at Cape Canaveral.

Hear the sounds and story of America entering the Space Age...

- the actual count-down and firing of a major ballistic missile
- the firing of the Atlas, the Jupiter, the Jupiter C, the Snark
- interviews with Dr. Wernher von Braun, Dr. Walter Dornberger, Kraft Ehricke, Gen. Donald N. Yates, Gen. Bernard Schriever.

Produced by Ward Botsford.

PL 11.120

At record dealers now. Write to Dept. S for complete catalogs.

VOX

236 West 55th Street New York 19, N. Y.

bebell & bebell
COLOR LABORATORIES

Technical Drawings Duplicated in brilliant photographic
COLOR

from original art, sketches, photoprints, transparencies.

ONE or 1000
slides, film strips, stereo, color prints, any size, any style.

(6-HOUR SERVICE AVAILABLE)

PERFORMANCE ON GOVERNMENT CONTRACTS.

Write for price list!

WAtkins 4-8573
108 W. 24th St., New York
Cables: Labsbebell, N.Y.

GROUND

The crucial ground environment for handling, launch and test of our major missile programs is managed at Cape Canaveral by Pan Am. The Guided Missiles Range Division of Pan American World Airways, Inc. has prime responsibility for managing, operating and maintaining the 5000-mile Atlantic Missile Range.

These operations and the division's continuing growth create unique engineering opportunities in the new and vital arts of missile range management, operation, maintenance and test data collection and reduction.

Qualified physicists, mathematicians and electronic and mechanical ground systems engineers should investigate these openings on the ground floor of the space age with Pan Am. Please address a confidential resume to Mr. C. R. Borders, Assistant Division Technical Manager, Pan American World Airways, Inc., Patrick Air Force Base, Cocoa, Florida, Dept. A-1.

PAN AM

GUIDED MISSILES RANGE DIVISION

PATRICK AIR FORCE BASE, FLORIDA

COMPONENT RELIABILITY BEGINS WITH

SPHERCO

SPHERICAL BEARINGS & ROD ENDS

- Precision-built for superior performance
- Solid race construction
- Wide range of designs, bore sizes, materials, etc.
- Prompt delivery schedules
- Engineering service

Cutaway View of TRE Male Rod End

WRITE FOR CAT. 257

SPHERCO

A PRODUCT OF SEALMASTER BEARING DIV. STEPHENS-ADAMSON MFG. CO.

RIDGEWAY AVENUE • AURORA, ILLINOIS

realized, thus minimizing spare parts stocks and maintenance facilities required to support these weapon systems. This centralized knowledge and control of assets could extend down even to the unit in the field, thus permitting interchange between squadrons on direction from the central manager of assets.

The single manager concept is, of course, not new. The term, "single manager," is used in the sense of sole and complete responsibility for providing logistic support to the operational unit for all direct mission hardware. "Direct mission hardware" means those items of equipment essential to the maintenance of an operational capability, as differentiated from so-called "housekeeping," or base-support, items, such as administrative communication equipment, administrative vehicles, etc.

As a cure for the problems of split responsibilities for and knowledge of an operation or a system, a single manager has often been prescribed. But, as is sometimes the case in medicine (rabies for example), this cure is also a little frightening. What is to prevent centralized management from becoming overloaded, and thus the source of errors and delays we are desirous of eliminating, when all the raw data, all the raw problems and all the analysis they require, and finally all the decisions, are its responsibility? These considerations, of course, tend to force decentralization and a compromise between what is desired and what is feasible.

Arrive at Centralized Management

A hard look at this question resulted in the conclusion that a completely centralized management would be feasible in this case *if* advantage were taken of recent developments in large-scale high-speed computer and data storage equipment. These improvements made feasible for the first time the development of a completely integrated data processing center capable of handling all raw data inputs, required analysis, and, finally, read outs of all information required by the central management organization for decision making.

This conclusion was reached over two years ago. How far along are we in achieving this capability? Briefly, the management organization has been established at San Bernardino Air Materiel Area in California. An IBM 705-2 Computer with associated data storage and print out equipment has been installed to support this operation. Programming of the computer and system shakedown will be completed by the end of the year.

In addition, to exploit the capabili-

ties of this organization and its equipment to react quickly and efficiently to the needs of the operational units in the field, action has been taken to provide exclusive use of direct teletype and transceiver communications between all elements of the system—from the operational units to the central logistic manager's data processing center and from there to the source of supply or maintenance. To reduce further the time between indication of need from the operational unit to delivery of the spares support required maximum use of direct source-to-user airlift.

We are confident that central management supported by electronic data processing equipment, direct automatic communications and airlift are the keys to reducing to a minimum the level of stocks of spare parts and the dollar impact of obsolescence on them.

We are not underestimating the trials and errors to which our best laid plans for ballistic missile support may be subjected. We expect to receive feedback from AMC "customers" (the operational units in the field)—not all complimentary. And we will change the system and change it fast whenever we can increase the number of ballistic missiles that can be maintained in a "go condition."

Based on a paper presented at the ARS Fall Meeting in Detroit, Mich., Sept. 15–18, 1958.

Liquid Propellant Agency Established

A Liquid Propellant Information Agency (LPIA), similar in scope and services to the Solid Propellant Information Agency (SPIA) established in 1946, has been set up at the Applied Physics Laboratory of the Johns Hopkins Univ., Silver Spring, Md., where SPIA is located. Both agencies are under the supervision of Keith G. Britton.

LPIA will act as a center for compiling and disseminating R&D information, both domestic and foreign, on liquid propellants and liquid rocket engines. A joint service effort, it is supported through a number of cognizant service offices: For the Air Force, WADC; for the Army, Office of the Chief of Ordnance; and for the Navy, BuAer, BuOrd, and ONR.

The services of the new agency, like those of SPIA, are available to all government agencies and contractors who send requests through one of the above offices. Additional information concerning LPIA may be obtained by writing to the agency at 8621 Georgia Ave., Silver Spring, Md.

RUGGED and RELIABLE
New!
TRANSISTORIZED
The A. W. HAYDON COMPANY'S
TRANSISTORIZED SUB-MINIATURE
ELECTRONIC TIME DELAY RELAYS!

SAVE SPACE AND WEIGHT!

	Miniature Series	Sub-Miniature Series
Cross Section	1 7/16" x 1 21/32"	3/32" x 1 3/16"
Length	2 1/4" long	2" long
Weight	6 ounces	3 ounces
WRITE FOR:	Bulletin AWH TD-503	Bulletin AWH TD-504

TEST-PROVED PERFORMANCE!
High Temperature: 125°C (250°F)
Vibration: 2000 CPS at 15 g.
Contact arrangements up to 4 pole double throw.
Unique transistorized R.C. time constant network.
Time Delays from 50 MS to 120 seconds. Longer Delays available.
Hermetically sealed housings.

The A. W. HAYDON Company
250 NORTH ELM STREET, WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices

response:
200 MSEC
TEMPERATURE TRANSDUCERS

Other Specifications:
Calibration accuracy: 0.1-1.0%, depending on temperature range
Repeatability and hysteresis: within calibration accuracy
Resistance at 32 F: 100 ±5 ohms
Nominal temperature-resistance coefficient: 0.0018/°C
Output: 0-5 vdc, when Arnoux 100-ohm TME is used.

The newest line of Arnoux temperature transducers—100-ohm resistance, 200-millisecond response—permits accurate measurement of transient temperatures such as those in missile and aircraft applications. The output signal is 0-5 vdc for as small a span as 180 F, when Arnoux transistorized TME-1 or TME-2 systems or similar equipment is used.

The fluid-immersion transducer (4101L-11), for static or moving fluid, is LOX compatible and available in two calibration ranges: −302 F to −285 F, −320 F to +500 F.

The air transducer (4101H-10) is for static to high-velocity gases.

The surface transducer (2101H-15) is for materials of limited area and thickness, and has great mounting versatility.

Both air and surface types are available in two calibration ranges: −100 F to +500 F, −100 F to +1200 F.

ARNOUX
ARNOUX CORPORATION
11924 WEST WASHINGTON BLVD., LOS ANGELES 66, CALIF.
Sales Offices: Beverly Hills, Calif. • Dallas • Great Neck, N.Y. • Seattle • Bryn Mawr, Pa.

Index to ASTRONAUTICS Vols. 2-3

(August 1957 through December 1958)

SUBJECTS

AMATEUR ROCKETRY:
- Aid for basement rocketeers, Feb. 1958, p. 23.
- Educating youthful rocketeers, July 1958, p. 39.

ARPA:
- National astronautical program begins to take shape, July 1958, p. 20.
- Round-up, July 1958, p. 20.

ARS:
- 1957 Annual meeting number, Dec. 1957.
- ARS urges national space flight program, Jan. 1958, p. 18.
- 10,000th Member, Nov. 1958, p. 36.
- Thirteenth time out, Nov. 1958, p. 38.
- 1958—A year of growth, Nov. 1958, p. 44.

ASTRONAUTICS:
- It's really empty space, Sept. 1957, p. 27.
- Why not astronautical engineers?, Sept. 1957, p. 52.
- Anthropology of astronautics, Nov. 1957, p. 26.
- Eighth International Astronautical Congress, Nov. 1957, p. 36.
- First look at American IAF papers, Nov. 1957, p. 36.
- Why astronautical engineers?, Nov. 1957, p. 38.
- Synthetic atmospheres for space ships, Nov. 1957, p. 48.
- Space flight goes to school, Dec. 1957, p. 44.
- ARS urges national space flight program, Jan. 1958, p. 18.
- Solid propellants and the conquest of space, Jan. 1958, p. 39.
- Human factors and space cabins, Jan. 1958, p. 42.
- Society and space exploration, Feb. 1958, p. 20.
- Flight space and the satellites, March 1958, p. 32.
- Legal aspects, March 1958, p. 32.
- Definition, March 1958, p. 32.
- Flight to the moon, April 1958, p. 32.
- Human crews for space ships, April 1958, p. 35.
- High-vacuum chamber, April 1958, p. 37.
- Laboratory for space research, April 1958, p. 37.
- We can't conquer space with missiles, June 1958, p. 20.
- NASA round-up, July 1958, p. 20.
- ARPA round-up, July 1958, p. 20.
- First space ship, X-15, July 1958, p. 35.
- Flight materials and structures, new era dawns for, Aug. 1958, p. 20.
- "Whiskers," a look at, Aug. 1958, p. 31.
- Gliding vehicles, high-speed, Aug. 1958, p. 34.
- NAS 16-man space science board, Sept. 1958, p. 14.
- Optimum paths to moon and planets, Sept. 1958, p. 18.
- What do you know about space?, Sept. 1958, p. 22.
- NASA act—"A historic step," Sept. 1958, p. 39.
- What power sources in space?, Oct. 1958, p. 24.
- Auguries of space flight, U.S.A., Oct. 1958, p. 38.
- Russian eye on space, Oct. 1958, p. 39.
- Amsterdam IAF Congress, Oct. 1958, p. 40.
- Peaceful talk of space, Oct. 1958, p. 40.
- Cosmonautics, Russian light on, Oct. 1958, p. 42.
- Answers to September space technology quiz, Oct. 1958, p. 56.
- A look ahead, Nov. 1958, p. 24.
- U.S. civilian space flight program, Nov. 1958, p. 30.
- Rocket engines for space flight, Nov. 1958, p. 37.
- Space flight, 1958, Nov. 1958, p. 46.
- 1958 Space legislation timetable, Nov. 1958, p. 49.

DRONES:
- Introducing the modern drone, June 1958, p. 22.
- Rocket propulsion for drones, June 1958, p. 24.
- Design criteria for drone rocket engines, June 1958, p. 27.
- Drones grow with weapon systems, June 1958, p. 30.
- Teal is a bird, June 1958, p. 31.
- Teal motor rundown, June 1958, p. 32.
- Drone radar and IR simulation, June 1958, p. 34.
- Scoring systems for missile evaluation, June 1958, p. 36.
- Combat surveillance and the drone, June 1958, p. 38.
- New drone guidance system, June 1958, p. 40.

EDUCATION:
- Why not astronautical engineers?, Sept. 1957, p. 52.
- Spawning ground for future scientists, Oct. 1957, p. 43.
- Why astronautical engineers?, Nov. 1957, p. 38.
- Space flight goes to school, Dec. 1957, p. 44.
- Space technology course, Dec. 1957, p. 44.
- Space age workshop, July 1958, p. 38.
- Educating youthful rocketeers, July 1958, p. 39.
- What do you know about space?, Sept. 1958, p. 22.
- Answers to September space technology quiz, Oct. 1958, p. 56.

ELECTRONICS:
- 'Brain' to map satellite orbit, Aug. 1957, p. 70.
- Spacistor, successor to transistor?, Sept. 1957, p. 34.
- Spawning ground for future scientists, Oct. 1957, p. 43.
- Electronics and the missile, May 1958, p. 20.
- Fundamentals of missile guidance, May 1958, p. 22.
- Electronic materials frontier, May 1958, p. 25.
- Radar, recent development in, May 1958, p. 28.
- Missile guidance, radio techniques for, May 1958, p. 30.
- Infrared missile guidance, May 1958, p. 33.
- Precision electronic equipment, May 1958, p. 41.
- Cures for which there are no diseases, May 1958, p. 41.
- Data processing in air defense systems, May 1958, p. 42.
- SAGE system, May 1958, p. 42.
- Drone radar and IR simulation, June 1958, p. 34.

FUELS:
- Propellants for tomorrow's rockets, Aug. 1957, p. 45.
- Fuels for the future, Nov. 1957, p. 35.
- Free radicals, Nov. 1957, p. 35.
- Recent advances, Jan. 1958, p. 34.
- Free radicals, A look at, Jan. 1958, p. 36.
- Solid propellants and the conquest of space, Jan. 1958, p. 39.
- Dual-thrust grain designs, March 1958, p. 26.
- I_{sp}: How high for chemical fuels?, Sept. 1958, p. 26.
- Cold propellants for hot performance, Sept. 1958, p. 28.
- Cryogenics, Sept. 1958, p. 28.
- Monopropellants, Sept. 1958, p. 34.
- Dark horse in propellant race, Sept. 1958, p. 34.
- Ramjet fuels: A brief survey, Sept. 1958, p. 36.
- A solid proposal, Sept. 1958, p. 38.
- Solids give liquids a boost, Oct. 1958, p. 30.
- Propellants and combustion, 1958, Nov. 1958, p. 56.

GROUND SUPPORT, HANDLING and LAUNCHING:
- Arctic tower, Oct. 1957, p. 66.
- Experimental missile firings: A functional analysis, Dec. 1958, p. 18.
- Atlas handling from factory to launch, Dec. 1958, p. 22.
- ICBM launch control, Dec. 1958, p. 24.
- Moon probe launch: What it takes, Dec. 1958, p. 26.
- Support systems for liquid engines, Dec. 1958, p. 28.
- AF logistics for ballistic missiles, Dec. 1958, p. 31.
- Universal engine handling equipment, Dec. 1958, p. 32.
- Toward universal missile test systems, Dec. 1958, p. 33.
- GSE design criteria, Dec. 1958, p. 34.
- Early testing means better ground support equipment, Dec. 1958, p. 36.
- Corrosion prevention for Polaris, Dec. 1958, p. 38.
- Polaris launching system, Dec. 1958, p. 40
- ASM handling and launching, Dec. 1958, p. 42.

GUIDANCE:
- Fundamentals of missile guidance, May 1958, p. 22.
- Missile guidance, radio techniques for, May 1958, p. 30.
- Infrared missile guidance, May 1958, p. 33.
- ICBM inertial guidance, May 1958, p. 45.
- Instrumentation and guidance, 1958, Nov. 1958, p. 54.

HUMAN FACTORS:
- Capt. Kittinger's 96,000-ft ascent, Aug. 1957, p. 56.
- On top of the world, Aug. 1957, p. 56
- Operation Farside, Sept. 1957, p. 12.
- First space man, Nov. 1957, p. 30.
- Maj. Simons ascent to 100,000 ft, Nov. 1957, p. 30.
- Weightlessness, Nov. 1957, p. 32.
- Synthetic atmospheres for space ships, Nov. 1957, p. 48.
- Human factors and space cabins, Jan. 1958, p. 42.
- Society and space exploration, Feb. 1958, p. 20.
- Life in Sputnik, Feb. 1958, p. 38.
- Flight to the moon, April 1958, p. 32.
- Farrell space voyage, April 1958, p. 32.
- Human crews for space ships, April 1958, p. 35.
- Laboratory for space research, April 1958, p. 37.
- High-vacuum chamber, April 1958, p. 37.
- Human factors, 1958, Nov. 1958, p. 58.

IGY:
- Who's who in the IGY, Aug. 1957, p. 60.
- First rocket firing, Aug. 1957, p. 64.
- Sounds off, Aug. 1957, p. 64.
- Vanguard instrument package, Aug. 1957, p. 66.
- 'Brain' to map satellite orbit, Aug. 1957, p. 70.
- Geodesy comes of age with Vanguard, Aug. 1957, p. 71.
- Shooting rockets in the sub-Arctic, Sept. 1957, p. 38.
- Notes, Sept. 1957, p. 86.
- Rocket and satellite technology in IGY 1982–83, Oct. 1957, p. 16.
- Arctic tower, Oct. 1957, p. 66.
- Notes, Oct. 1957, p. 76.
- Russians talk about rockets at IGY conference, Nov. 1957, p. 85.
- Push-button rocketry, Feb. 1958, p. 44.
- Navy IGY rockets, Feb. 1958, p. 44.
- IGY program to date, March 1958, p. 21.
- Russian eye on space, Oct. 1958, p. 39.
- Harvest from the IGY: Earth satellite and rocket research programs, Nov. 1958, p. 34.

INSTRUMENTATION:
- Vanguard instrument package, Aug. 1957, p. 66.
- Soviet satellite instrumentation, Feb. 1958, p. 32.
- Microlock, how it works, March 1958, p. 25.
- Fundamentals of missile guidance, May 1958, p. 22.
- Computers and simulators aid in missile development, May 1958, p. 38.
- Data processing in air defense system, May 1958, p. 42.
- SAGE system, May 1958, p. 42.
- ICBM inertial guidance, May 1958, p. 45.
- Instrumenting for large-scale captive missile tests, Part I, May 1958, p. 48; Part II, Oct. 1958, p. 35.
- Drone radar and IR simulation, June 1958, p. 34.
- Radioactive tracers—new aid to rocket instrumentation, July 1958, p. 30.
- Instrumentation and guidance, Nov. 1958, p. 54.

MAGNETOHYDRODYNAMICS:
- Introducing magnetohydrodynamics, Oct. 1958, p. 18.

MATERIALS AND PROCESSES:
Spacistor, successor to transistor?, Sept. 1957, p. 34.
High temperature materials for aeronautical applications, chart, Sept. 1957, p. 48.
Notorious unreliability of complex equipment in missiles, Feb. 1958, p. 26.
WADC radiological hot cell, Feb. 1958, p. 31.
Fueling rockets, new wrinkle in, July 1958, p. 34.
New era dawns for flight materials and structures, Aug. 1958, p. 20.
Metal forming for the missile age, Aug. 1958, p. 22.
Enter fiber-polymer structures, Aug. 1958, p. 25.
Plastics for liquid rocket engines, Aug. 1958, p. 26.
High-temperature corrosion-resistant brazing, Aug. 1958, p. 28.
Glass gets hot, Aug. 1958, p. 30.
Glass and ceramics, Aug. 1958, p. 30.
"Whiskers," a look at, Aug. 1958, p. 31.
Corrosion prevention for Polaris, Dec. 1958, p. 38.
METEOROLOGY:
Meteorological rocket system, low-cost, Oct. 1958, p. 26.
MISSILES:
AF ICBM program, Aug. 1957, p. 34.
Communications, toward improved missile, Aug. 1957, p. 54.
ICBM: Giant step into space, Aug. 1957, p. 34.
Ten years of missile progress, Sept. 1957, p. 24.
Missiles mean business, Sept. 1957, p. 28.
Who's making what, chart of, Sept. 1957, p. 30.
Solving missile production problems, Oct. 1957, p. 24.
ABMA: Integrated weapon arsenal, Oct. 1957, p. 40.
AF missile development center, Nov. 1957, p. 39.
From bricks to rascals, Nov. 1957, p. 42.
Air-to-surface missiles, complete story of, Nov. 1957, p. 42.
"Flying" missiles on the ground, Nov. 1957, p. 46.
Recent advances, Jan. 1958, p. 34.
Soviet missiles on parade, Jan. 1958, p. 51.
Missile reliability, Feb. 1958, p. 26.
Notorious unreliability of complex equipment, Feb. 1958, p. 26.
Lessons of Peenemuende, March 1958, p. 18.
Who's who in missile contracting, April 1958, p. 24.
Reliable ignition, April 1958, p. 30.
Getting missiles off to good start, April 1958, p. 30.
Electronics and the missile, May 1958, p. 20.
Fundamentals of missile guidance, May 1958, p. 22.
Missile guidance, radio techniques for, May 1958, p. 30.
Infrared missile guidance, May 1958, p. 33.
How computers and simulators aid in missile development, May 1958, p. 38.
ICBM inertial guidance, May 1958, p. 45.
Instrumenting for large-scale captive missile tests, Part I, May 1958, p. 48; Part II, Oct. 1958, p. 35.
Supporting research and ballistic missiles, July 1958, p. 24.
Off-site missile test center, setting up an, July 1958, p. 26.
Nondestructive tests and quality control, July 1958, p. 32.
Reliability, the way to missile, Aug. 1958, p. 36.
SAGE to Bomarc to target, Oct. 1958, p. 34.
Experimental missile firings: A functional analysis, Dec. 1958, p. 18.
Atlas handling from factory to launch, Dec. 1958, p. 22.
ICBM launch control, Dec. 1958, p. 24.
Moon probe launch: What it takes, Dec. 1958, p. 26.
Pioneer picture story, Dec. 1958, p. 26.
AF logistics for ballistic missiles, Dec. 1958, p. 31.
Toward universal missile test systems, Dec. 1958, p. 33.
Mace helps pioneer GSE design criteria, Dec. 1958, p. 34.
Corrosion prevention for Polaris, Dec. 1958, p. 38.
Polaris launching system, Dec. 1958, p. 40.
ASM handling and launching, Dec. 1958, p. 42.
X-15: Mach 7 aircraft, Dec. 1958, p. 46.
Space beacon, Dec. 1958, p. 21.
NASA:
Steps into space, June 1958, p. 41.
Program proposal, June 1958, p. 41.
National astronautical program begins to take shape, July 1958, p. 20.
Round-up, July 1958, p. 20.
NASA act—"A historic step," Sept. 1958, p. 39.
Staffing up, Nov. 1958, p. 29.
U.S. civilian space flight program, Nov. 1958, p. 30.
PATENTS:
Helicopter efficiency, Aug. 1957, p. 16.
Rocket fuel transfer system, Aug. 1957, p. 16.
Refractory coat for jet engine walls, Sept. 1957, p. 82.
Spin launching of rockets, Sept. 1957, p. 82.
High-energy liquid propellant system, Oct. 1957, p. 82.
Nozzle, direction changing propulsive, Oct. 1957, p. 82.
Wind tunnel, turbojets power, Nov. 1957, p. 64.
A-A missile cable barrier, Nov. 1957, p. 64.
Escape from high-speed aircraft, Dec. 1957, p. 78.
Feeding system, liquid propellant rocket, Jan. 1958, p. 80.
Rocket launching unit, Jan. 1958, p. 80.
Helicopter rotor, jets propel, Feb. 1958, p. 72.
Rocket motor for return burning, Feb. 1958, p. 72.
Missile tracking system, March 1958, p. 66.
Efficient dual jet units, April 1958, p. 74.
Auxiliary jets keep rocket on target, May 1958, p. 88.
Testing guidance equipment, May 1958, p. 88.
Increasing engine thermal efficiency, June 1958, p. 74.
Missile optical systems, moisture protection for, July 1958, p. 60.
Reducing rocket fuel rate, Aug. 1958, p. 70.
Optical system for missile guidance, Aug. 1958, p. 70.
Shipboard missile launcher, Aug. 1958, p. 71.
Furfural and permanganate, Sept. 1958, p. 100.
Extinguishing propellant fires, Sept. 1958, p. 100.
Analog computers solve equations, Nov. 1958, p. 130.
PROPULSION:
Underwater propulsion moves ahead, Sept. 1957, p. 35.
Toward better ramjet control systems, Oct. 1957, p. 37.
Three unconventional engines, Oct. 1957, p. 44.
Monatomic ramjet project, Dec. 1957, p. 28.
Recent advances, Jan. 1958, p. 34.
Solid propellants and the conquest of space, Jan. 1958, p. 39.
Vanguard propulsion, aspects of, Jan. 1958, p. 44.
A tactical Pc control system, Feb. 1958, p. 34.
Dual-thrust engines, why not?, March 1958, p. 26.
Jet propulsion looks to future, March 1958, p. 29.
Conventional propulsion systems, chart, March 1958, p. 30.
Rocket propulsion for drones, June 1958, p. 24.
Testing giant rocket engines, July 1958, p. 28.
Propellants and combustion, Nov. 1958, p. 56.
Ramjets, 1958, Nov. 1958, p. 60.
Support systems for liquid engines, Dec. 1958, p. 28.
RADAR:
Columbia develops improved radar, Oct. 1957, p. 8.
Recent developments, May 1958, p. 28.
Drone radar and IR simulation, June 1958, p. 34.
RELIABILITY:
Notorious unreliability of complex equipment, Feb. 1958, p. 26.
Nondestructive tests and quality control, July 1958, p. 32.
Missile reliability, way to, Aug. 1958, p. 36.
R&D:
ABMA: Integrated weapons arsenal, Oct. 1957, p. 40.
AF Missile Development Center, Nov. 1957, p. 39.
AF Cambridge Research Center projects, Dec. 1957, p. 28.
NACA Lewis Flight Propulsion Lab, Feb. 1958, p. 40.
AFCRC: Test tube for tomorrow, Part I, March 1958, p. 36; Part II, April 1958, p. 40.
Supporting research and ballistic missiles, July 1958, p. 24.
Off-site missile test center, setting up an, July 1958, p. 26.
First space ship, X-15, July 1958, p. 35.
NACA designs for tomorrow, Sept. 1958, p. 44.
NACA Ames Aeronautical Lab, Sept. 1958, p. 46.
NASA Langley Aeronautical Lab, Oct. 1958, p. 21.
X-15: Mach 7 aircraft, Dec. 1958, p. 46.
ROCKETS:
Industry leader looks at future, Aug. 1957, p. 42.
Propellants for tomorrow's rockets, Aug. 1957, p. 45.
First IGY rocket firing, Aug. 1957, p. 64.
Operation Farside, Sept. 1957, p. 12.
When will rockets go commercial?, Sept. 1957, p. 20.
Underwater propulsion, Sept. 1957, p. 35.
Shooting rockets in the sub-Arctic, Sept. 1957, p. 38.
Rocket motors don't have to be expensive, Sept. 1957, p. 42.
Lark engine details, Sept. 1957, p. 45.
Rocket and satellite technology in IGY 1982–83, Oct. 1957, p. 16.
Russians talk about rockets at IGY conference, Nov. 1957, p. 85.
High-altitude sounding rockets project, Dec. 1957, p. 28.
Recent advances, Jan. 1958, p. 34.
Race into space, Jan. 1958, p. 34.
Solid propellants and the conquest of space, Jan. 1958, p. 39.
Aid for basement rocketeers, Feb. 1958, p. 23.
A tactical Pc control system, Feb. 1958, p. 34.
Push-button rocketry, Feb. 1958, p. 44.
Navy IGY rockets, Feb. 1958, p. 44.
Lessons of Peenemuende, March 1958, p. 18.
Dual-thrust engines, why not?, March 1958, p. 26.
Reliable ignition, April 1958, p. 30.
Design criteria for drone rocket engines, June 1958, p. 27.
Teal is a bird, June 1958, p. 31.
Teal motor rundown, June 1958, p. 32.
Testing giant rocket engines, July 1958, p. 28.
Radioactive tracers—New aid to rocket instrumentation, July 1958, p. 30.
Nondestructive tests and quality control, July 1958, p. 32.
Fueling rockets, new wrinkle in, July 1958, p. 34.
Space age workshop, July 1958, p. 38.
Educating youthful rocketeers, July 1958, p. 39.
Plastics for liquid rocket engines, Aug. 1958, p. 26.
Rocket mail history—In stamps, Aug. 1958, p. 40.
Military jumping jacks?, Aug. 1958, p. 42.
Rocket jump belt for military, Aug. 1958, p. 42.
I_{sp}: How high for chemical fuels?, Sept. 1958, p. 26.
Old problems for big solid rockets, Sept. 1958, p. 31.
Meteorological rocket systems, low-cost, Oct. 1958, p. 26.
Harvest from the IGY, Nov. 1958, p. 34.
IGY rocket research program, Nov. 1958, p. 35.
Rocket engines for space flight, Nov. 1958, p. 37.
Liquid rockets, 1958, Nov. 1958, p. 50.
Solid rockets, 1958, Nov. 1958, p. 52.
X-15: Mach 7 aircraft, Dec. 1958, p. 46.

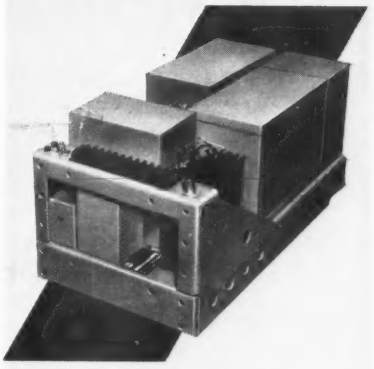
SATELLITES:
Vanguard vehicle rundown, Aug. 1957, p. 62.
Vanguard instrument package, Aug. 1957, p. 66.
Vanguard ground computer center, Aug. 1957, p. 70.
'Brain' to map satellite orbit, Aug. 1957, p. 70.
Geodesy comes of age with Vanguard, Aug. 1957, p. 71.
It's really empty space, Sept. 1957, p. 27.
Earth satellites, seeking natural, Sept. 1957, p. 27.
Rocket and satellite technology, Oct. 1957, p. 16.
Ear to the sky, Oct 1957, p. 28.
Minitrack system report, Oct. 1957, p. 28.
Will satellites be short-lived?, Oct. 1957, p. 31.
Men of Project Vanguard, Oct. 1957, p. 32.
Vanguard control system, Oct. 1957, p. 34.
Problem of launching an earth satellite, Part I, Nov. 1957, p. 18; Part II, Dec. 1957, p. 34.
Meaning of "Sputnik," Nov. 1957, p. 22.
Spotlight on satellites, Nov. 1957, p. 50.
Three 1000-lb satellites, Dec. 1957, p. 28.
Dog in space, Dec. 1957, p. 30.
Sputnik II and Muttnik, Dec. 1957, p. 30.
Sputnik and Vanguard: A comparison, Dec. 1957, p. 32.
Launching characteristics: Sputnik I, Russian IRBM vs. Viking 11 and Vanguard, Dec. 1957, p. 37.
After Sputnik—What?, Dec. 1957, p. 38.
Eyes on the sky—Moonwatch team, Dec. 1957, p. 40.
Building the Vanguard vehicle, Dec. 1957, p. 42.
Vanguard propulsion, aspects of, Jan. 1958, p. 44.
Sputnik II through Russian eyes, Jan. 1958, p. 48.
First satellite results are in, Jan. 1958, p. 50.
Make-ready for satellite launching, Feb. 1958, p. 28.
Soviet satellite instrumentation, Feb. 1958, p. 32.
Life in Sputnik, Feb. 1958, p. 38.
1958 Alpha, March 1958, p. 22.
Explorer I, March 1958, p. 22.
Explorer I repot, April 1958, p. 20.
Sputnik III launched, July, 1958, p. 12.
Explorers, report from the, July 1958, p. 40.
First data on Sputnik II, July 1958, p. 68.
Explorer IV launched, Sept. 1958, p. 14.
Synodic satellites, Oct. 1958, p. 28.
Jupiter-C, run-down on, Oct. 1958, p. 32.
Behind the Red satellites, Nov. 1958, p. 32.
Harvest from the IGY, Nov. 1958, p. 34.
IGY earth satellite program, Nov. 1958, p. 34.
1958 Satellite launching chart, Nov. 1958, p. 48.
Space beacon, Dec. 1958, p. 21.
TELEMETRY:
Missile communications, toward improved, Aug. 1957, p. 54.
Microlock, how it works, March 1958, p. 25.
Radio telemetry, some problems in, May 1958, p. 36.
Data processing in air defense system, May 1958, p. 42.
TESTING:
"Flying" missiles on the ground, Nov. 1957, p. 46.
Captive missile tests, May 1958, p. 48.
Off-site missile test center, setting up an, July 1958, p. 26.
Testing giant rocket engines, July 1958, p. 28.
THERMODYNAMICS:
Engineering for high temperature age of flight, Part I, Aug. 1957, p. 50; Part II, Sept. 1957, p. 46.
TRACKING:
Vanguard computer center, Aug. 1957, p. 70.
Columbia develops improved radar, Oct. 1957, p. 8.
Ear to the sky, Oct. 1957, p. 28.
Minitrack system, Oct. 1957, p. 28.
Eyes on the sky, Dec. 1957, p. 40.
Moonwatch team, Dec. 1957, p. 40.
Microlock, how it works, March 1958, p. 25.
Omni-directional tracking systems, March 1958, p. 34.
Radar, recent development in, May 1958, p. 28.
Drone radar and IR simulation, June 1958, p. 34.
WIND TUNNELS:
New wind tunnel for ABMA, Feb. 1958, p. 37.
MISCELLANEOUS:
Woods Hole conference maps AF plans, Sept. 1957, p. 4.
Von Kármániana, June 1958, p. 42.

AUTHORS

ACKLEY, R. A
Instrumenting for large-scale captive missile tests, Part I, May 1958, p. 48; Part II, Oct. 1958, p. 35.
ARNOWITZ, LEONARD
The Vanguard control system, Oct. 1957, p. 34.
BAGBY, FREDERICK L. and Associates
Engineering for the high temperature age of flight, Part I, Aug. 1957, p. 50; Part II, Sept. 1957, p. 46.
BARKER, LEONARD M.
Recent developments in radar, May 1958, p. 28.
BENEDIKT, E. T., see KLEMPERER, W. B.
BENNETT, WILLIAM R.
After Sputnik—what?, Dec. 1957, p. 38.
BERL, WALTER G. and RENICH, WALDO T.
Ramjet fuels: A brief survey, Sept. 1958, p. 36.
BLENKUSH, P. G., see FIUL, A.
BOELTER, L. M. K.
Space flight goes to school, Dec. 1957, p. 44.
BONNELL, C. R. and LLOYD, D. E.
Scoring systems for missile evaluation, June 1958, p. 36.
BOTTARI, LOUIS DE
A tactical Pc control system, Feb. 1958, p. 34.
BROWN, LAWRENCE S.
Instrumentation and guidance, 1958, Nov. 1958, p. 54.
BROWN, POWEL
Support systems for large liquid engines, Dec. 1958, p. 28.
BRYSON, ARTHUR E. and OUELLETTE, GERALD A.
Optimum paths to the moon and planets, Sept. 1958, p. 18.
BURGESS, ERIC
"Flying" missiles on the ground, Nov. 1957, p. 46.
The way to missile reliability, Aug. 1958, p. 36.
CAIDIN, MARTIN
The first space ship, July 1958, p. 35.
CARTER, JAMES M.
I_{sp}: How high for chemical fuels?, Sept. 1958, p. 26.
CLARK, JOHN D.
Dark horse in the propellant race, Sept. 1958, p. 34.
COOPER, JOHN COBB
Flight space and the satellites, March 1958, p. 32.
COX, DONALD
Men of Project Vanguard—The Martin team, Oct. 1957, p. 33.
CRASK, JAMES A.
Rundown on the Teal motor, June 1958, p. 32.
CREMER, GEORGE D., see LONG, JOHN V.
DEBUS, KURT H.
Experimental missile firings: A functional analysis, Dec. 1958, p. 18.
DOBRONRAVIN, PYOTR
Russian eye on space, Oct. 1958, p. 39.
DOBYNS, R. S. and MCBRIDE, J. A.
Rocket motors don't have to be expensive, Sept. 1957, p. 42.
DORNBERGER, WALTER R.
The lessons of Peenemuende, March 1958, p. 18.
DRYDEN, HUGH L.
Space flight: A look ahead, Nov. 1958, p. 25.
U.S. civilian space flight program, Nov. 1958, p. 30.
DUNN, CHESTER J.
Atlas handling from factory to launch, Dec. 1958, p. 22.
DUNN, LOUIS G.
Supporting research and ballistic missiles, July 1958, p. 24.
EDSON, LEE and OPPENHEIM, A. K.
Von Kármániana, June 1958, p. 42.
EHRICKE, KRAFFT A.
The anthropology of astronautics, Nov. 1957, p. 26.
Space flight, 1958, Nov. 1958, p. 46.
ELA, CAPT. DENNETT K.
Polaris launching system, Dec. 1958, p. 40.
FELD, DAVID, see LEVIN, KENNETH L.
FIUL, A. and BLENKUSH, P. G.
Drones grow with the weapon system, June 1958, p. 30.
FORDHAM, C. E., see SCHOPP, L. W.
FRIEDMAN, HERBERT
The Vanguard instrumentation package, Aug. 1957, p. 66.
Soviet satellite instrumentation, Feb. 1958, p. 32.
FROHMBERG, R. P.
Nondestructive tests and quality control, July 1958, p. 32.
FUECHSEL, KARL M.
High-speed gliding vehicles, Aug. 1958, p. 34.
GALLO, JOSEPH E.
ICBM launch control, Dec. 1958, p. 24.
GERARD, GEORGE
New era dawns for flight materials and structures, Aug. 1958, p. 20.
GERATHEWOHL, SIEGFRIED J.
Weightlessness, Nov. 1957, p. 32.
GOETZ, ERNEST A.
ICBM inertial guidance, May 1958, p. 45.
GONGWER, CALVIN A.
Underwater propulsion moves ahead, Sept. 1957, p. 35.
GRAY, ROBERT
Toward universal missile test systems, Dec. 1958, p. 33.
GREENING, CHARLES P., see MOORE, JOHN R.
GREENMAN, NORMAN L.
Enter fiber-polymer structures, Aug. 1958, p. 25.
GREY, JERRY
Jet propulsion looks to the future, March 1958, p. 29.
GROSS, ROBERT A.
Three unconventional engines, Oct. 1957, p. 44.
GUSTAVSON, JOHN
Why not astronautical engineers?, Sept. 1957, p. 52.
Synthetic atmospheres for space ships, Nov. 1957, p. 48.
HAITE, WILLIAM F.
A solid proposal, Sept. 1958, p. 38.
HALEY, ANDREW G.
Space flight: A look ahead, Nov. 1958, p. 28.
HARFORD, JAMES J.
ARS takes Manhattan—again, Dec. 1957, p. 18.
Thirteenth time out, Nov. 1958, p. 38.
HARRIS, GORDON L.
ABMA: Integrated weapons arsenal, Oct. 1957, p. 40.
HERSEY, IRWIN
The meaning of "Sputnik," Nov. 1957, p. 22.
Dog in space, Dec. 1957, p. 30.
Aid for basement rocketeers, Feb. 1958, p. 23.
National astronautical program begins to take shape, July 1958, p. 20.
NACA Ames Aeronautical Lab, breeding ground for space flight, Sept. 1958, p. 46.
Amsterdam IAF Congress, Oct. 1958, p. 40.
HIBBS, ALBERT R.
Harvest from the IGY, the earth satellite program, Nov. 1958, p. 34.
HOFFMAN, GEORGE A.
A look at "whiskers," Aug. 1958, p. 31.
HUTH, JOHN H.
What power sources in space?, Oct. 1958, p. 24.
ISAACS, HERBERT H. and MATZENAUER, JAMES O.
Design criteria for drone rocket engines, June 1958, p. 27.
ISAKOV, P.
Life in Sputnik, Feb. 1958, p. 38.
JOHNSON, CHARLES
Early testing means better ground support equipment, Dec. 1958, p. 36.
KANNER, GIDEON
Why astronautical engineers?, Nov. 1957, p. 38.
KANTROWITZ, ARTHUR
Introducing magnetohydrodynamics, Oct. 1958, p. 18.
KAPLAN, JOSEPH
Space flight: A look ahead, Nov. 1958, p. 28.
KIMBALL, DAN A.
An industry leader looks at the future, Aug. 1957, p. 42.
KLEIN, MARTIN L.
Cures for which there are no diseases, May 1958, p. 41.
KLEMPERER, W. B. and BENEDIKT, E. T.
Synodic satellites, Oct. 1958, p. 28.

KOELLE, H. H.
Sputnik and Vanguard: A comparison, Dec. 1957, p. 32.
KONECCI, EUGENE B.
Human factors and space cabins, Jan. 1958, p. 42.
KRIEGER, F. J.
Behind the Red satellites, Nov. 1958, p. 32.
LAMAR, CAPT. KIRBY
Combat surveillance and the drone, June 1958, p. 38.
LEE, Y. C.
Liquid rockets, 1958, Nov. 1958, p. 50.
LETAW JR., HARRY
The electronic materials frontier, May 1958, p. 25.
LEVIN, KENNETH L. and FELD, DAVID
ASM handling and launching, Dec. 1958, p. 42.
LLOYD, D. E., see BONNELL, C. R.
LONG, JOHN V. and CREMER, GEORGE D.
High-temperature corrosion-resistant brazing, Aug. 1958, p. 28.
LUSSER, ROBERT
The notorious unreliability of complex equipment, Feb. 1958, p. 26.
MACDONALD, COL. HENRY GORDON
AF logistics for ballistics missiles, Dec. 1958, p. 31.
MATZENAUER, JAMES O., see ISAACS, HERBERT H.
MCBRIDE, J. A., see DOBYNS, R. S.
MCFEE, RAYMOND H.
Missile guidance by infrared, May 1958, p. 33.
MCKINNEY JR., C. DANA and MOREY, LOREN E.
Old problems for big solid rockets, Sept. 1958, p. 31.
MCMURTREY JR., A. WINFIELD
Drone radar and IR simulation, June 1958, p. 34.
MENGEL, JOHN T.
Ear to the sky, Oct. 1957, p. 28.
MICHAEL, DONALD N.
Society and space exploration, Feb. 1958, p. 20.
MICKLE, E. A., see SZEGO, G. C.
MOORE, JOHN R. and GREENING, CHARLES P.
Fundamentals of missile guidance, May 1958, p. 22.
MOREY, LOREN E., see MCKINNEY JR., C. DANA
MORRIS, BROOKS T.
Ramjets, 1958, Nov. 1958, p. 60.
NEWELL JR., HOMER E.
Harvest from the IGY, the rocket research program, Nov. 1958, p. 35.
NEWMAN, R. S.
Why not dual-thrust engines?, March 1958, p. 26.
NICHOLS, M. H. and RAUCH, L. L.
Some problems in radio telemetry, May 1958, p. 36.
O'KEEFE, JOHN A.
Geodesy comes of age with Vanguard, Aug. 1957, p. 71.
OPPENHEIM, A. K., see EDSON, LEE
ORDWAY III, FREDERICK I.
From bricks to Rascals, Nov. 1957, p. 42.
OUELLETTE, GERALD A., see BRYSON, ARTHUR E.
PENDRAY, G. EDWARD
When will rockets go commercial?, Sept. 1957, p. 20.
PFEFFER, IRWIN and WEST, GEORGE P.
How computers and simulators aid in missile development, May 1958, p. 38.
PICKERING, WILLIAM H.
Space flight: A look ahead, Nov. 1958, p. 27.
POPPOFF, I. G.
Low-cost meteorological rocket systems, Oct. 1958, p. 26.
POURNELLE, J. E.
Human crews for space ships, April 1958, p. 35.
RAMO, SIMON
ICBM: Giant step into space, Aug. 1957, p. 34.
Space flight: A look ahead, Nov. 1958, p. 25.
RAUCH, L. L., see NICHOLS, M. H.
REAGAN, JAMES F.
Introducing the modern drone, June 1958, p. 22.
RECHTIN, EBERHARDT
Radio techniques for missile guidance, May 1958, p. 30.
REDDING JR., PASCHAL E.
Getting missiles off to a good start, April 1958, p. 30.
REICH, HERBERT
Laboratory for space research, April 1958, p. 37.
RENICH, WALDO T., see BERL, WALTER G.
RITCHEY, HAROLD W.
Solid propellants and the conquest of space, Jan. 1958, p. 39.
SALZMAN, JEROME
Solids give liquids a boost, Oct. 1958, p. 30.
SCHOPP, L. W. and FORDHAM, C. E.
GSE design criteria, Dec. 1958, p. 34.
SELLARS, CAPT. R. F.
Educating youthful rocketeers, July 1958, p. 39.
SHERMAN, ARTHUR
Rocket propulsion for drones, June 1958, p. 24.
SHONERD, DAVID E.
Radioactive tracers—New aid to rocket instrumentation, July 1958, p. 30.
SIDES, VICE ADM. JOHN H.
Ten years of missile progress, Sept. 1957, p. 24.
SIMONS, LT. COL. DAVID G.
Human factors, 1958, Nov. 1958, p. 58.
SLAUGHTER, H. C.
Corrosion prevention for Polaris, Dec. 1958, p. 38.
SLOOP, JOHN L.
Cold propellants for hot performance, Sept. 1958, p. 28.
Propellants and combustion, 1958, Nov. 1958, p. 56.
SPRATTLING JR., W., see TENENBAUM, D. M.
STAPP, COL. JOHN P.
On top of the world, Aug. 1957, p. 56.
The first space man, Nov. 1957, p. 30.
STEHLING, KURT R.
Aspects of Vanguard propulsion, Jan. 1958, p. 44.
STEVER, H. GUYFORD
Space flight: A look ahead, Nov. 1958, p. 26.
SUMMERFIELD, MARTIN
Problems of launching an earth satellite, Part I, Nov. 1957, p. 18; Part II, Dec. 1957, p. 34.
SZEGO, G. C. and MICKLE, E. A.
A look at free radicals, Jan. 1958, p. 36.
TENENBAUM, D. M. and SPRATTLING JR., W.
Testing giant rocket engines, July 1958, p. 28.
TOTH, ROBERT C.
Toward improved missile communications, Aug. 1957, p. 54.
TRUAX, CAPT. ROBERT C.
We can't conquer space with missiles, June 1958, p. 20.
TUHY, IVAN E.
Solid rockets, 1958, Nov. 1958, p. 52.
VALLEY, GEORGE E.
Data processing in air defense systems, May 1958, p. 42.
VASU, GEORGE, see WENTWORTH, CARL B.
VON BRAUN, WERNHER
Rundown on Jupiter-C, Oct. 1958, p. 32.
Space flight: A look ahead, Nov. 1958, p. 26.
VON KÁRMÁN, THEODORE
Space flight: A look ahead, Nov. 1958, p. 24.
YORK, HERBERT F.
Space flight: A look ahead, Nov. 1958, p. 27.
WENTWORTH, CARL B. and VASU, GEORGE
Toward better ramjet control systems, Oct. 1957, p. 37.
WEST, GEORGE P., see PFEFFER, IRWIN
WIESNER, JEROME B.
Electronics and the missile, May 1958, p. 20.
WITHEE, W. W.
Setting up an off-site missile test center, July 1958, p. 26.
YAFFEE, MICHAEL L.
IGY sounds off, Aug. 1957, p. 64.
Missiles mean business, Sept. 1957, p. 28.
Filling the gap, Dec. 1957, p. 28.
AFCRC: Test tube for tomorrow, Part I, March 1958, p. 36; Part II, April 1958, p. 40.
ZABLE, WALTER J.
Omni-directional tracking systems, March 1958, p. 34.
ZEILBERGER, ERNEST J.
Plastics for liquid rocket engines, Aug. 1958, p. 26.
ZEITLIN, ALEXANDER
Metal forming for the missile age, Aug. 1958, p. 22.
ZWICKY, FRITZ
Propellants for tomorrow's rockets, Aug. 1957, p. 45.

New ADVANCED DESIGN "B" LINE 60 AND 400 CPS



HIGH POWER TRANSISTOR MAGNETIC SERVO AMPLIFIER

For AC servo motor control — 50 watts to 3000 watts

FEATURING
- Extreme reliability
- Wider ambient temperature range
- Faster response
- Smaller size at higher power ratings
- Higher gains
- Improved core design
- Silicon rectifiers used exclusively
- Greater flexibility
- Ideally suited for operating with Diehl Servo Motors

Signal Input AC or DC
Military Specifications
Provisions for System Feedback • Completely Static • Output 115V AC Phase Reversible

For complete 60 cps and 400 cps specs request Bulletin S-961.

MA

MAGNETIC AMPLIFIERS, INC.

632 TINTON AVENUE • NEW YORK 55, N.Y. • CYPRESS 2-6610

West Coast Division

136 WASHINGTON ST. • EL SEGUNDO, CAL. • OREGON 8-2665

ENGINEERS
and
SCIENTISTS
there's genuine opportunity at
General Mills

The Mechanical Division of General Mills, Minneapolis, Minnesota, needs senior level staff personnel for creative design and development in the following fields:

Advanced Digital Computer Systems Design

Advanced Digital Computer Circuit Development

Advanced Pulse and Video Circuit Development

Advanced Electromechanical Computer Development

Advanced Inertial Navigational System Development

Aerodynamicists

Optical and Infra-Red Equipment Engineering

Telemetry Systems Engineers

Test and Evaluation of Basic Electronic and Electromechanical Components

Positions available for *purely technical* and for *technical-supervisory* work—job titles and salary provide *equal* opportunity for advancement in both.

Positions exist in Engineering Department which is engaged in advanced design and development of military weapons and reconnaissance systems, communications, controls, guidance, navigation, and special purpose digital computers. Work is mainly military, with some special commercial instrumentation and control.

If you have at least five years' experience in creative design or development—a good understanding of fundamentals and ability to apply them—learn more about the opportunity and long range security offered at General Mills. You'll like our people, our interesting, nonroutine projects—and you'll like Minnesota, land of lakes and pine. In Minnesota everyone takes time to enjoy life.

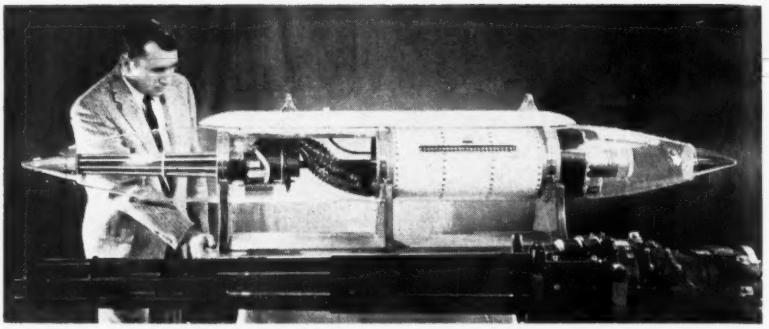
Write for more facts.

MECHANICAL DIVISION General Mills

Personnel Department (A2)

2003 E. Hennepin, Minneapolis 13, Minnesota

New equipment



Lightweight Cannon: For fighter and other light aircraft, this 7.62-mm Vulcan cannon rides in a jettisonable pod 90 by 10 in. It fires 6000 to 10,000 rounds per min. General Electric Co., Missile and Ordnance Systems Dept., 3190 Chestnut St., Philadelphia 4, Pa.

Closed-Circuit TV: Camera system automatically adjusts to changing light conditions; monitor has a polarized filter. Geometric distortion at all brightness levels is not more than 2 per cent. Kintel Div. of Cohu Electronics, Inc., 5725 Kearny Villa Rd. Box 623, San Diego 12, Calif.

Silicon Solar Cells: Rugged cells convert 10 per cent of incident radiant energy, and provide an output of approximately 9 watts per sq ft of active cell area in bright sunlight. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Synthetic Mica Sheet: Mica flakes are formed into firm sheet (Synthamica) by a series of operations similar to those used in the manufacture of paper. Not in production yet. Synthetic Mica Co., Div. of Mycalex Corp., Clifton, N.J.

Transient Permanent Magnistor: Dime-sized component for electronic computers, magnetic-tape systems, high-speed printers, magnetic proximity detectors and other equipment. Stores energy indefinitely and withstands operating temperatures beyond 220 F. Potter Instrument Co., Inc., Sunnyside Blvd., Plainview, L.I., New York.

Test Turntable: Designed to determine transfer functions of inertial devices against programmed sinusoids or step functions. Multimode 26-in. platform for loads up to 500 lb, turning rates from 0 to 2 rps; positional accuracy of ± 10 sec of theoretical. J. W. Fecher, Inc., 6592 Hamilton Ave., Pittsburgh 6, Pa.

Super-Fast Electrostatic Recorder

The Army Signal Corps recently demonstrated an ultra-high-speed electronic teleprinting device, developed and produced by Burroughs Corp., capable of printing 3000 words per min, and adaptable so as to feed raw data to digital computer output systems as well as type out calculations of electronic brains. Called Electrostatic Recording, the super-fast machine utilizes a reader employing photocells instead of keys to read tapes. The printer itself performs via a bank of electrode "guns," each aiming its beam at a corresponding spot on the paper and capable of firing any letter or number. After the volley of letters, each line of text passes rapidly over powdered ink and a heated roller, and appears a split second later as readable text.

Universal Engine Handling

(CONTINUED FROM PAGE 32)

The Mobiltainers are the most important and interesting part of the system. Although not shock-mounted, they can be towed on fair surfaces at speeds up to 25 mph, and can be carried by commercial flat-bed trucks and C-125 or larger aircraft.

The Mobiltainers are so-called free-breathing containers, which can be dehumidified when the access door is sealed. The access door can be opened quickly at any time to allow checking of engine components.

Partially constructed of a very tough and strong fiber aggregate called Paraglas developed by Air Logistics, the Mobiltainers are extremely lightweight. For example, the previous steel container used for the Atlas booster weighed 7760 lb empty, while the small Mobiltainer weighs only 1510 lb. As far as room is concerned, the small Mobiltainer with its adapters allows shipping two vernier engines and loose ducting with the Atlas booster, whereas before these units had to be shipped separately.

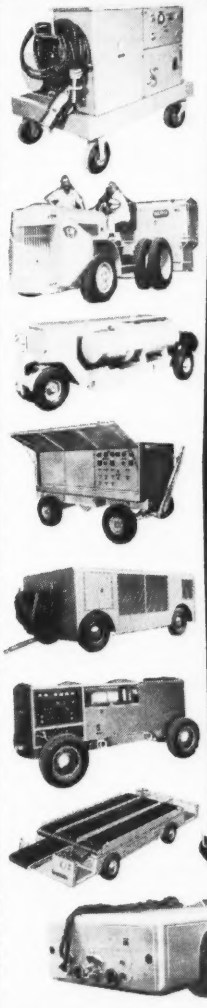
This system can be used to handle and ship re-entry vehicles as well as rocket engines. Moreover, an adaptation of Air Logistics' rail transfer system will eliminate the need for overhead slings in taking re-entry vehicles or engines from the Mobiltainers and installing them on the missile. The system thus leads to complete standardization in the handling and shipping of the nose and aft ends of AF ballistic missiles. Finally, the Mobiltainers can be adapted readily for transporting jet engines.

The free-breathing method of protecting engines from moisture and other contaminants appears at present the only uncertainty associated with this universal handling and transportation system. This uncertainty has been countered by having rocket engine manufacturers develop free-breathing desiccated closures and covers for propulsion components. A qualification program now being planned should uncover and provide the basis for correcting any weakness in the system.

AOA Awards

The American Ordnance Assn. has presented the Rice Memorial Medal for contributions to missile development to Hugh L. Dryden, NASA Deputy Administrator, and the Crozier Medal for Distinguished Service in the field of armament preparedness to Maj. Gen. John B. Medaris, Commander, Army Ordnance Missile Command.

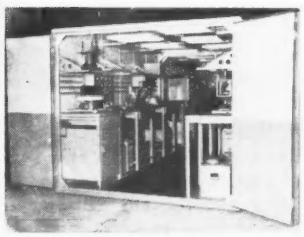
Missile & Aircraft
Ground Support Equipment



Complete Systems:

- 400 cycle, 800 cycle and Higher Frequencies
- DC Power Supplies
- Pneumatic Power
- Hydraulic Power
- Aircraft Energizers
- Nacelle Testers
- Refrigeration, Heating & Air Conditioning
- Cargo Loading and Unloading Equipment

Competent Bogue Engineers are located near you — Call for their skills at your convenience.

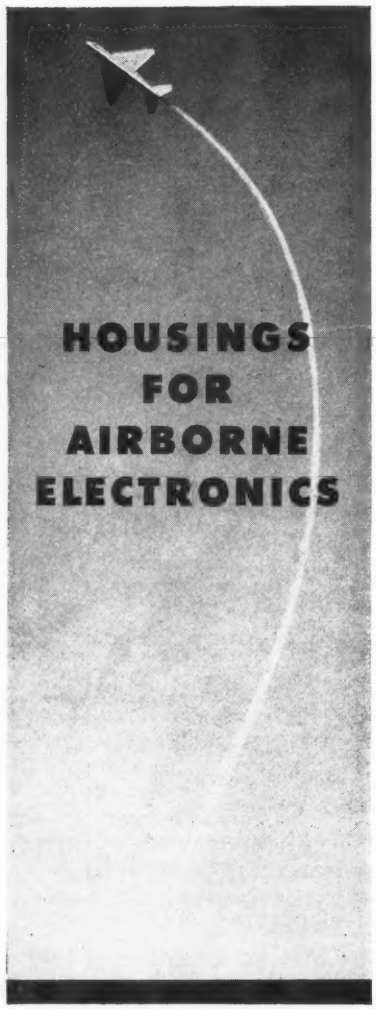


Electronic Vans

PRECISION ELECTRICAL EQUIPMENT
Bogue
SINCE 1892

BOGUE

BOGUE ELECTRIC MANUFACTURING COMPANY
PATERSON 3, NEW JERSEY



KAMAN

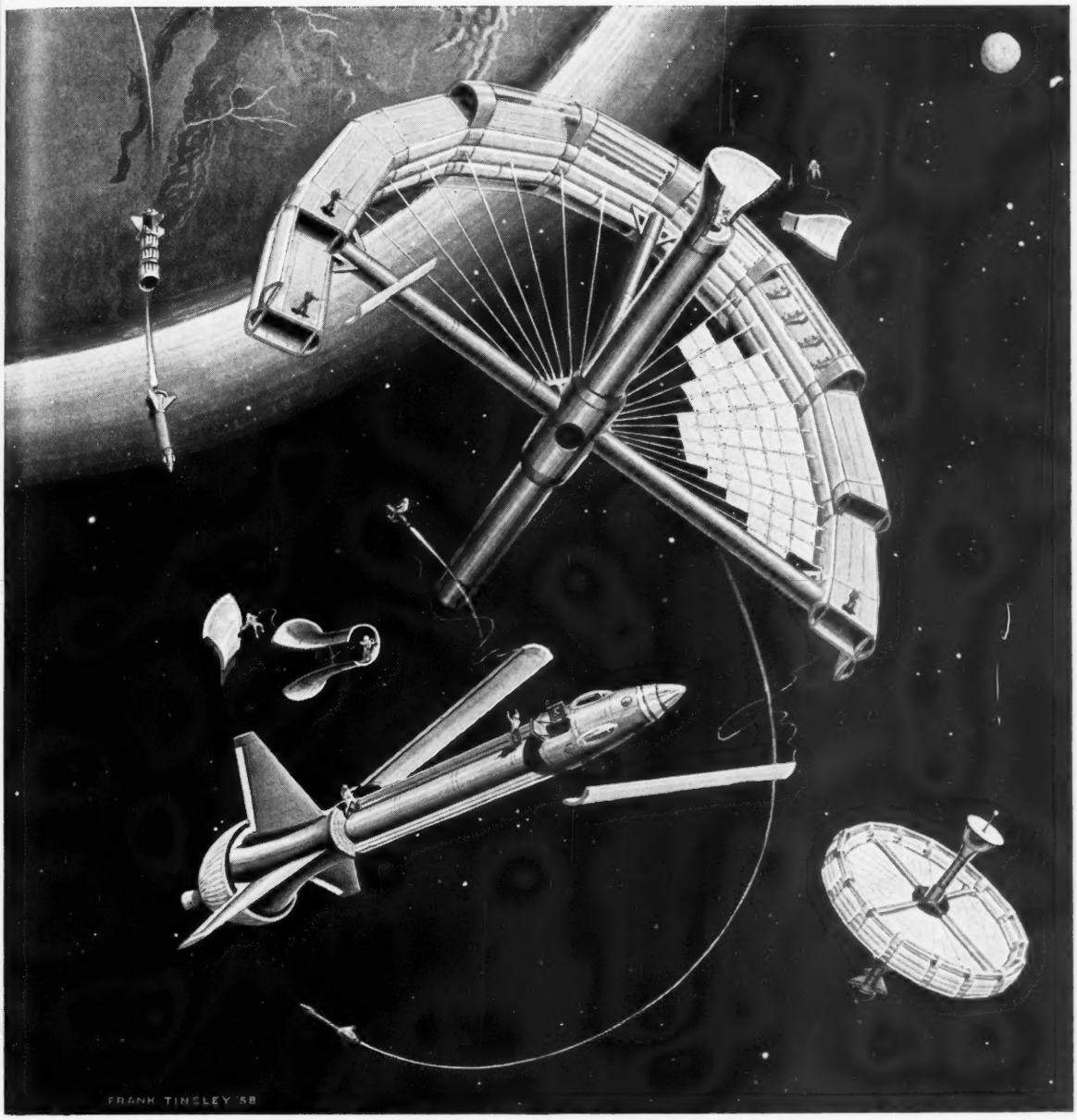
Long a prime military contractor, Kaman is also a leading subcontractor to outstanding aircraft and missiles producers. Experience in processing and fabrication of magnesium and aluminum coupled with complete manufacturing and assembly facilities of over 500,000 square feet enable us to produce the most complicated housings and other assemblies for airborne electronic equipment to the most precise tolerances.

May we send you our 16 page illustrated brochure of equipment and facilities?

THE KAMAN AIRCRAFT CORPORATION
SUBCONTRACT DIVISION
BLOOMFIELD 7, CONNECTICUT

Index To Advertisers

Aerojet-General Corp. ..... Back Cover
D'Arcy Adv. Co., Los Angeles, Calif.
Aeronutronic Systems, Inc. 92
Honig, Cooper, Harrington & Miner Adv., Los Angeles, Calif.
Amphenol Electronics Corp. 68
Burton, Brown Adv., Chicago, Ill.
Arma Division, American Bosch Arma Corp. ..... Third Cover
Doyle, Kitchen & McCormick Inc., New York, N. Y.
Arnoux Corp. 101
Kay Christopher Adv., Hollywood, Calif.
Barber-Colman Co. 85
Howard H. Monk & Assoc. Inc., Rockford, Ill.
Bebell & Bebell Color Labs. 99
Ronan Howard Assoc., New York, N. Y.
Beckman Instruments Inc., Scientific-Process Div. 16
Charles Bowles Adv. Inc., Los Angeles, Calif.
Bell Aircraft Corp. 52, 94
Baldwin, Bowers & Strachan Inc., Buffalo, N. Y.
B-J Electronics, Borg-Warner Corp. 65
Leland Oliver Co., Santa Ana, Calif.
Bogue Electric Mfg. Co. 107
W. N. Hudson Adv., Ascutney, Vt.
Callery Chemical Co. 97
Ketchum, MacLeod & Grove Inc., Pittsburgh, Pa.
Consolidated Electrodynamics Corp. 61, 67
Hixson & Jorgensen Inc., Los Angeles, Calif.
Cook Electric Co. 7
H. M. Wexberg Adv., Chicago, Ill.
Data-Control Systems Inc. 69
Robert MacPherson, Fanwood, N. J.
Davidson Mfg. Co. 74
Sylvester Adv. Agency, Pasadena, Calif.
Diversey Engineering Co. 13
Roark & Colby Adv., Chicago, Ill.
Electrol Inc. 83
Bruce Woodin & Assoc., Woodstock, N. Y.
Food Machinery & Chemical Corp. 11
The McCarty Co., San Francisco, Calif.
The Garrett Corp., AiResearch Mfg. Divs. 15
J. Walter Thompson Co., Los Angeles, Calif.
General Film Laboratories Corp. 70
Ross, Reisman Co., Los Angeles, Calif.
General Mills Inc. 106
Knox Reeves Adv. Inc., Minneapolis, Minn.
A. W. Haydon 101
Cory Snow, Inc., Boston, Mass.
Hughes Aircraft Co. 81
Foote, Cone & Belding, Los Angeles, Calif.
Hughes Aircraft Co., Products Div. 50
Foote, Cone & Belding, Los Angeles, Calif.
International Business Machines Corp. 88-89
Benton & Bowles Inc., New York, N. Y.
International Telephone & Telegraph Corp. 10
J. M. Mathes Inc., New York, N. Y.
Kaman Aircraft Corp. 108
Charles Palm & Co., Bloomfield, Conn.
Linde Co. 87
J. M. Mathes Inc., New York, N. Y.
Litton Industries Inc. 95
Calkins & Holden Inc., Los Angeles, Calif.
Lockheed Aircraft Corp., Missile Systems Div. 57
Hal Stebbins Inc., Los Angeles, Calif.
Los Alamos Scientific Laboratory 53
Ward Hicks Adv., Albuquerque, N. M.
Magnetic Amplifiers 105
De Garmo Inc., New York, N. Y.
Marquardt Aircraft Co. 8-9
Grant Adv. Inc., Hollywood, Calif.
National Aeronautics and Space Administration 63
M. Belmont ver Standig Inc., Washington, D. C.
North American Aviation Inc.
Autonetics Div. 51
Missile Div. 4
Rocketdyne Div. 59
Batten, Barton, Durstine & Osborn Inc., Los Angeles, Calif.
Norton Co. 75
James Thomas Chirurg Co., Boston, Mass.
Nortronics, A Division of Northrop Aircraft Inc. 82
Erwin, Wasey, Ruthrauff & Ryan Inc., Los Angeles, Calif.
Pacific Automation Products Inc. 55
Anderson-McConnell Adv. Agency Inc., Hollywood, Calif.
Pan American World Airways, Inc., Guided Missiles Div. 100
Parker Seal Co. 91
Lester-Voorhees Co., Los Angeles, Calif.
Radio Corporation of America 64
Al Paul Lefton Co. Inc., Philadelphia, Pa.
Robbins Aviation 86
Rolle Mfg. Co. 1
The Harry P. Bridge Co., Philadelphia, Pa.
Southwest Products Co. 86
O. K. Fagan Adv. Agency, Los Angeles, Calif.
Space Technology Laboratories 77
Gaynor & Ducas Inc., Beverly Hills, Calif.
Stearns Roger Mfg. Co. 73
Mosher, Reimer & Williamson, Denver, Colorado
Stephens-Adamson Mfg. Co. 100
Connor Assoc., Inc., Aurora, Ill.
Swedlow Plastics Co. 2
Willard G. Gregory & Co., Los Angeles, Calif.
System Development Corp. 79
Stromberger, LaVene, McKenzie, Los Angeles, Calif.
Telecomputing Corp. 49
Anderson-McConnell Adv. Agency, Hollywood, Calif.
Texas Instruments Inc. 93
Don L. Baxter Inc., Dallas, Tex.
Thiokol Chemical Corp. ..... Second Cover
Dancer-Fitzgerald-Sample Inc., New York, N. Y.
Trans-Sonics Inc. 66
Louis K. Frank Co., Boston, Mass.
Vox Productions Inc. 99
Fairfax Inc., New York, N. Y.
Washington Technological Associates 71
Dawson, McLeod & Strivers, Washington, D. C.
Wiancko Engineering Co. 62
Nelson Advertising Agency, Los Angeles, Calif.



STEPS IN THE RACE TO OUTER SPACE

Assembling a station in space

This imaginative but technically accurate illustration shows a permanent satellite (center) being constructed in orbit around the earth. It generates its own heat and electricity from solar rays. Basic vegetation (such as algae) for oxygen as well as protein-rich foods are grown in hydroponic tubes in upper level "greenhouses."

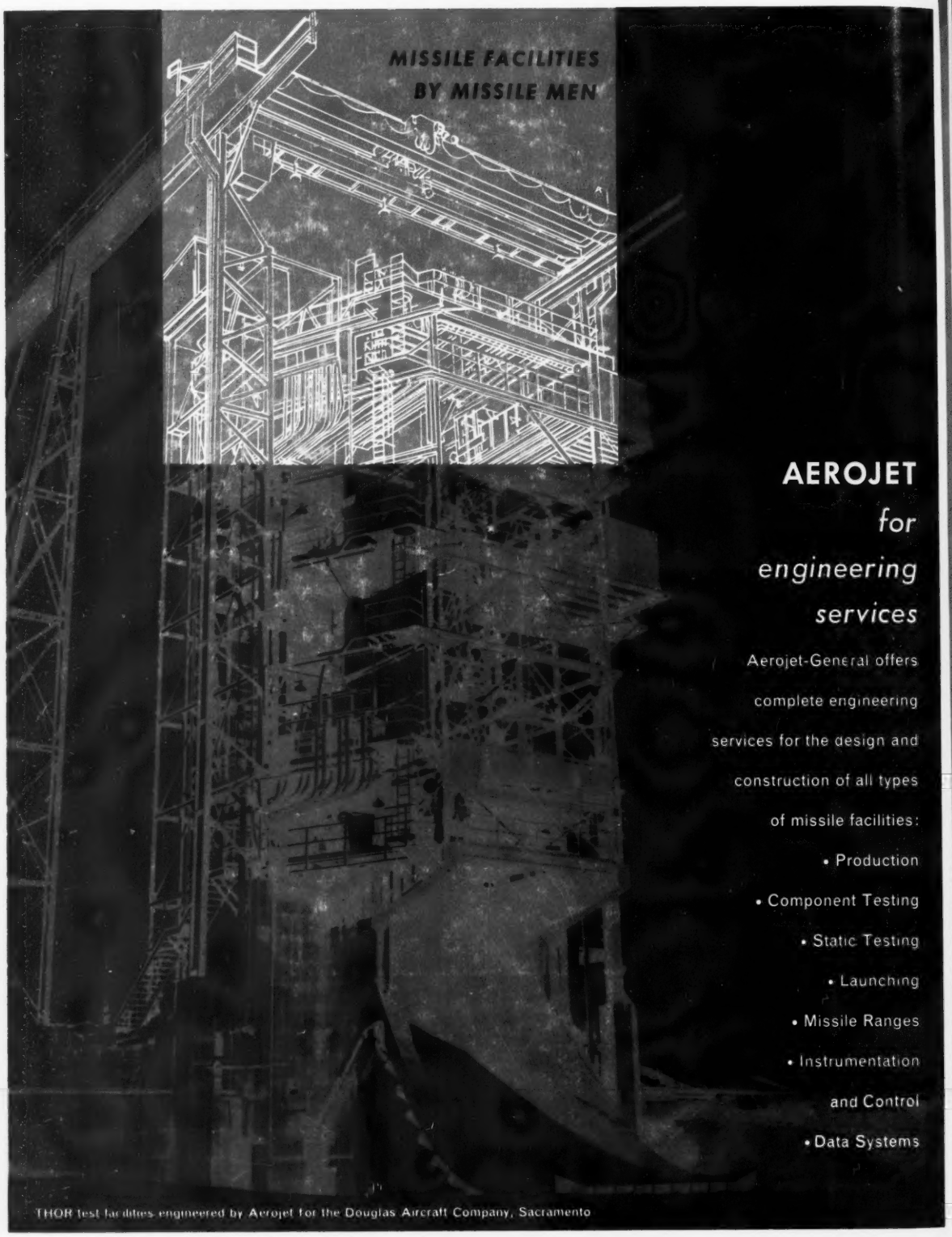
New vistas in astronomy will be opened up by such a space station, because of perfect conditions for photography and spectroscopy. It will also provide unique conditions for advanced research in physics, electronics, weather prediction, etc. Three such stations, properly placed, could blanket the entire world with nearly perfect TV transmission.

Atomic rocket vehicles with prefabricated skin layers (lower center) provide building materials for the station, then return (bottom) to earth. Similar craft will service an established station (lower right), docking by electromagnetic pull in lower section of station's axis.

ENGINEERS • SCIENTISTS

ARMA needs key men to augment a broad research program in missile guidance and space technology. As designer and developer of all-inertial navigation systems for TITAN and ATLAS ICBM's, ***ARMA*** provides a stimulating atmosphere where creative talents can develop. Write to E. C. Lester, Professional Placement, AS-1, ***ARMA*** Division, Garden City, N. Y. A Division of American Bosch Arma Corporation.

AMERICAN BOSCH ARMA CORPORATION



AEROJET

for engineering services

Aerojet-General offers complete engineering services for the design and construction of all types of missile facilities:

- Production
- Component Testing
- Static Testing
- Launching
- Missile Ranges
- Instrumentation and Control
- Data Systems

THOR test facilities engineered by Aerojet for the Douglas Aircraft Company, Sacramento

AEROJET-GENERAL CORP.*

THE GENERAL TIRE

A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

Engineers, scientists—investigate outstanding opportunities at Aerojet. (Plants at Azusa and near Sacramento, Calif.)

DEC 17 1958